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A STUDY OF THE EFFECTS ON OUTPUT OF INDUSTRIAL WORKERS WHEN CLOSED CIRCUIT TELEVISION IS USED TO PERMIT REMOTE OBSERVATION OF WORKER PERFORMANCE

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SUMMARY

This study was designed to observe the effects of closed-circuit television on worker performance. The method used permitted management to record remotely the quantity of output units. The literature search revealed no quantitative evaluation of this application of closed-circuit television.

Union reaction forced removal of the television equipment after functioning for only one day. Output data were obtained during an experimental span of eight weeks. Analyses were made to ascertain if the television system, or resulting reactions to its installation, affected worker performance. The data obtained during the television functioning and during the two weeks after removal were compared to that for the periods before the removal and for the third and fourth weeks after it.

The results reject the null hypothesis that the output of industrial workers is not affected when a closed-circuit television system is installed to permit remote observation of worker performance.

The expansion of closed-circuit television applications in industry, and the possibilities for continued growth, emphasize the need for industrial engineering and related sciences to be aware of this potential. Full use of these techniques and acquisition of knowledge of their limitations should be continued.

CHAPTER I

INTRODUCTION

Although the use of closed-circuit television is widespread, there may be some confusion regarding the nature of this type of equipment. A definition from Lewis (1) is as follows: "Closed-circuit television provides for the electronic transmission and reception of images within a definitely prescribed area or system not available for general viewing."

Closed-circuit television is being used in industry for process observation, training, televised conferences, surveillance, and other tasks. Observations of workers have been made but the effects on output apparently have not been quantitatively evaluated. Such an evaluation has been attempted with this experiment.

The problem consisted of determining if there was a significant difference in worker output while the television camera was functioning or immediately following, and the periods before and after the television installation. The introduction of the closed-circuit television system was the independent variable and the rate of worker output the dependent variable.

The investigation centered around two major ideas: (1) a closed-circuit television application, and (2) worker motivation. It was a continuation of the ideas developed by Penuela (2), since both were investigations of a technique that might affect worker output. Penuela evaluated the effects of the presence of a time study analyst on worker output. In this study, the installation of a closed-circuit television system was the technique evaluated.

The null nypothesis was made that the rate of output of industrial workers, during observation of that output by a closed-circuit television camera with the monitor being observed by supervision at a remote location, does not differ significantly from the rate of output of the same workers when the television camera is not present.

The purpose of this investigation was to evaluate the use of closed-circuit television for direct observation of the output of industrial workers. The data that were evaluated consisted of the rates of output of the workers before installation of the television system, during its functioning, and subsequent to its removal.

CHAPTER II

LITERATURE REVIEW

The literature review is divided into four sections:

1. Literature concerned with applications of closed-circuit television.
2. Literature concerned with rate of output of industrial workers.
3. Hawthorne studies.
4. Penuela

Applications of Closed-Circuit Television

Meyers and Chipp (3), in the foreward to their book, discuss the status of closed-circuit television in the year 1957, as follows:

> In reviewing the story of closed-circuit television we find that it is an infant prodigy which, as far as commercial applications are concerned, was born shortly after the end of World War II.
>
> In the brief span of 10 years we have seen this type of television application grow from one fixed camera, staring continously at a water-level gage or a smoke stack, to installations involving 100 cameras and even more monitors, with a switching system which enables the viewer to select any one of 100 subjects which he wishes to view.
>
> Industrial TV cameras have evolved from heavy, cumbersome "chains" designed for TV broadcasting studios and requiring a crew of half-a-dozen or more technicians, to tiny self-contained units scarcely larger than a package of king-size cigarettes, which can be controlled from a distance by one non-technical operator. The controls by which the viewer can direct the movements of the camera, its lenses and iris, and even screen, are recent developments which signal the maturity of the systems phase of closed-circuit television.
>
> While closed-circuit TV has its limitations (some of which will

probably be eliminated by future technological developments) it is already one of the most efficient forms of communication devised by man.

There have been numerous applications of closed-circuit television, some of which are depicted by the charts from Meyers and Chipp (3), shown as Figure 1.

Uses described by McGhee (4) include underwater exploration, microscopy, telescopy, furnace control, education, and aerial reconnaissance. Noll (5) suggests that closed-circuit television could be used to advantage by industrial engineers but he does not indicate that it has been used for observations of rate of output of workers. Other applications include:

1. Soviet nuclear icebreakers with television camera aboard a helicopter.
2. Welding instruction.
3. Aid to optical tooling.
4. Control of an automotive body assembly line in England.
5. Remote banking operations.
6. Remote controls of special weapons.
7. Use by dentists to illustrate and spot cavities.

Some of the most informative references regarding closed-circuit television applications are the brochures published by firms manufacturing the equipment. Although most of this literature is for advertising and therefore not suitable for research reference, objective and quantitative-type literature regarding observations of people has not been found, and for this reason, some of the sales brochures will be briefly discussed.

Sylvania Electric Products Incorporated Publishes a booklet entitled, A Handbook of Quick Facts on Direct Wire Television which discusses various applications. One section is entitled "Production Control" and the emphasis is on observation of inaccessible items, safety, speed of locating parts in stock, and viewing automated processes.

An advertisement by Sylvania in the July 1962 Factory Magazine suggests that "direct wire TV speeds production and discourages work lags." This would seem to indicate that television is used to encourage workers to higher production, but the handbook, previously mentioned, makes no reference to such applications. The lack of reference in the handbook reinforces the idea that employers, and hence companies selling to employers, are prone to deemphasize any spying implications.

The Du Mont Television and Radio Corporation publishes a handbook similar to Sylvania's entitled, Industrial Television Handbook. It describes similar applications and details operating techniques. The Philco Corporation also publishes a handbook.

The Thompson, Ramo, Woolridge Corporation publishes an interesting booklet entitled, Educational TV ---- A Primer. The Pennsylvania State University has published a report on closed-circuit television for teaching university courses. The South Carolina Education television Center has published a booklet on educational television. Educational television is not the subject of this thesis but many references to it are revealed in any literature survey of closed-circuit television. Additionally, educational television systems could be very similar to industrial systems and the development of closed-circuit television for each application is complementary to the other.

One of the most complete industrial systems is described in the June 1962 issue of Factory Magazine. It is installed at the Hughes Aircraft Company's El Segundo, California, plant. Three operating channels and 15 monitors link assembly, purchasing, machine loading, quality control, and other functions. Inventory control and production scheduling are major functions of this system, but it also is used in other areas for reporting and remote monitoring. In addition, it provides an up-to-the-minute bulletin board in every part of the plant. No mention is made in this article of the impact of the television system on worker efficiency.

A similar but smaller application has been made by Douglas Aircraft Company, where television is employed to check machined parts by relaying information between the shops and engineering areas.

Rochette (6), suggests closed-circuit television for observing people at work. He states that one union (not named) does not want its workers being watched by unknown persons at unknown places. He also suggests duplicate monitors so that the workers can see what the observer is observing. No studies are mentioned and no actual installations of this type are cited.

The references to brochures and magazine articles have been included in this literature review because of the lack of more comprehensive works. All of these articles have been non-quantitative and have provided no basis for conclusions regarding closed-circuit television applications. Three books on closed-circuit television applications, located in this literature review, are: Meyers and Chipp (3);

Zworykin, Ramberg, and Flory (7); and an RCA report (8). The first two approach the subject in a similar manner and were written within one year of each other (1957 - 1958). They outline the principal fields of application, as of 1957 - 1958, describe available equipment, and attempt to forecast future development. The RCA book was also written in 1958 and covers similar applications. It contains more complete descriptions of equipment. None of the books makes any reference to installations providing motivation for improved worker output.

An interesting application for closed-circuit television has been developed at the University of Wisconsin by Smith (9), (10), and associates. They have adapted television and other electronic devices to the study of human motions. Delayed sensory feedback is being studied and images have been delayed and displaced by use of closed-circuit television. The central problem being studied is the way in which animal motion is organized and regulated to conform to the geometric properties of the environment. Dr. Smith has not attempted to evaluate the effects of closed-circuit television when used to observe worker output.

No evidence of the quantitative evaluation of the use of a closed circuit television system to observe rate of output of workers has been found in a literature search. One of the major reasons, suggested by equipment manufacturers' representatives, for the lack of such installations is the reluctance of employers to risk the displeasure of workers and unions because of the implication that these employers would be "spying".

The installation described in this study was made in an industrial environment in a section of a plant where only women were employed. The television camera was placed in an open area, observing one worker. All others in the area were aware of its presence. The monitor was placed in the General Foreman's office. That the implication of the employer's spying was present in this study is shown by the fact that some of the workers immediately objected, through the union.

Devices and Techniques Used to Influence Rate of Output of Industrial Workers

This study has been concerned with the effects on rate of output caused by introduction of a closed-circuit television system. It is therefore appropriate to consider the devices and related techniques that might be comparable to the closed-circuit television when used to observe rate of output. In considering these devices and techniques it is desirable to compare them to the television system with respect to their effect on rate of output. In order to make a quantitative comparison, one or more experiments are required for each item. Such a comparison is beyond the scope of this study. For these reasons, the devices and techniques that are comparable from the standpoint of some apparent effect on rate of output will be discussed.

Stop Watch (with Time Study Techniques)

Time study was introduced by Taylor toward the end of the nineteenth century and the stop watch was used extensively by him to time operations. In his Shop Management (11), Taylor discusses the use of a stop watch for timing laborers in the material yard of the Bethlehem Steel Company. In the same reference (12), he describes the use of a stop watch in performing the detailed operations of time study.

The idea of using a stop watch for timing work operations is generally attributed to Taylor but it may have been used prior to him. Drury (13) quotes Harrington Emerson, who was a contemporary of Taylor, as follows:

> I had made time studies as to a great variety of operations twenty years before I met Mr. Taylor; I was on my third big plant betterment before Mr. Taylor's Shop Management appeared. I welcomed this work as a great and brilliant contribution to the subject.

The stop watch is still an important time study device, used by analysts and recommended by most texts on the subject. Barnes (14); Lowry, Maynard, and Stegemerten (15); Production Handbook (16); and others describe and recommend stop watches.

Penuela (17) and others have emphasized the fact that serious doubt exists regarding the validity of conclusions about time study techniques. He pointed out that factors other than those of the techniques may also be present to affect rate of output. This conclusion is also stated by Gomberg (18), and reinforced by Myers (19) by identification of variations influencing the performance of workers.

Camera

Frank B. Gilbreth (20) used both the still camera and the motion picture camera extensively. In operating his contracting firm, Gilbreth recognized the value of photographic records. He used pictures to keep office employees in touch with conditions on the job, for advertising purposes, for records in case of lawsuits, and for records of conditions of adjoining buildings.

Gilbreth developed micromotion study (21), using the motion picture camera, and the chronocyclegraph (22). Both of these techniques employ other devices with the camera. The other devices include lights, timers, and clocks but in each case the camera is the most important device.

Instruction Cards

The instruction cards advocated by Taylor were instructions to insure that the best method was used. Gilbreth (23) quotes Taylor, regarding instruction cards, as follows:

> The instruction card can be put to wide and varied use. It is to the art of management what the drawing is to engineering, and like the latter, should vary in size and form according to the amount and variety of information which it is to convey.

The planning department (24), a keystone in Scientific Management, has to rely on some type of instruction card to convey the details of the operational plan to the shop. Current industrial practice often calls for the use of a combination instruction and inspection document so that the work may be "bought off" by an inspector when completed.

An example of a typical instruction card, an operation sheet used by the Lockheed Georgia Company, is shown in Figure 2. This sheet is an instruction to the fabrication shop operators and contains identification information, operation descriptions, tooling information, time standards, material description, and a block for "buy-off" by the production supervisor or by a quality control inspector.

This operation sheet is only one example of shop instruction cards. The content, clarity, arrangement, and completenses of instruction cards (of whatever form) and the emphasis placed upon them may have an effect on rate of output.

Process Charts

The process chart, developed by Gilbreth, is a device used to influence rate of output and might be comparable to introduction of a television system. This is especially true when the workers are informed of its use and shown its content. Mogensen (25) defines a process chart in this way: "This is a detailed record indicating the sequence of any process - a device for visualizing a process as a means of improving it."

Barnes (26) describes the process chart as a device for recording, in a compact manner, a process as a means of better understanding and improving it.

Mogensen (27) discusses process charts as does Barnes (28), and Production Handbook (29).

Machine and Process Timing

Counting and timing were employed by Taylor (30) to determine the best speeds and feeds of machine tools for maximum output.

Counting and timing techniques and devices are often used in industry today. Such measuring can vary from a manual count to a recording indicator and can measure anything that can be reduced to an electrical, pneumatic, hydraulic, or other type of impulse.

The more automatic devices were developed as the equipment on which they were used became more complex. A simple cam-type counter for a punch press or a duplicating machine is common today, as are the recording potentiometers used in the process industries.

Wage Incentives

Wage incentives have been used and are still being used as a means of increasing rate of output. They began as piece rates and were improved by Towne (31), Taylor (32), Gantt (33), Bedaux (34), and others (35).

Lillian Gilbreth makes the following statements (36) regarding wage incentives:

> The prompter the reward, the greater the stimulus. The reward will become associated with the fatigue in such a way that the worker will really get, at the time, more satisfaction out of his fatigue than he will discomfort; at the least, any dissatisfaction over his fatigue will be eliminated by the constant and first thought of the reward which he has gotten through his efforts.

The earlier advocates of wage incentives assumed that the wage was the most important factor in motivating production workers. Beach (37) believes that in the past human relations aspects have been largely overlooked. He also holds that industrial engineers have done little to solve the problems of restriction of output, intergroup conflicts, bringing the "whole man" into the incentive program, and equitable distribution of awards for improvement ideas. He suggests that what is needed to make wage incentives work more effectively is a combination of the contributions which the engineering profession has been making with the knowledge and insights which the behavioral scientists are making available. He further suggests that a positive form of employee participation and ego-involvement in the operation of incentive programs is an ingredient necessary to success.

Gomberg (38), (39), and (40) calls wage incentive plans relatively ineffective. He says they tend to liberate more drive than straight day work but still leave untapped a reservoir of productivity. He reiterates one conclusion of Roethlishberger (41) that workers are not completely motivated by the logics of cost and efficiency but that their behavior is actually dictated by the informal rules of the social organization.

The Scanlon Plan, discussed by Mihlon (42), tends to reinforce this idea of employee participation and involvement. Scanlon worked out a group incentive plan under which the employee is fully informed regarding company operations and profits, and shares the profits in the form of a bonus for increased output. Additionally, as a major part of this plan employees are encouraged to submit improvement ideas and a rather elaborate system for handling these ideas is included.

Additional articles on wage incentives are those by: Byrt (43), Whyte (44), Lesieur (45), and Rothe (46).

It is beyond the scope of this study to discuss the merits of wage incentives but they do constitute a technique that supposedly has been prominent in affecting rate of output of industrial workers.

Hawthorne Studies

With the advent of the Hawthorne studies and related books (41), (47), (48), and (49) in the fields of psychology, sociology, and industrial engineering, a new emphasis began to be placed upon the reasons for changes in the rate of output of workers.

The Hawthorne studies (41), (47), and (48) were an extensive group of experiments conducted at the Hawthorne Works of the Western Electric Company in Cicero, Illinois. They were begun in 1927 and continued through 1932. The investigation began with five workers and expanded until it included about 20,000 individual employees.

These studies began as an extension of the illumination experiments conducted in connection with the National Academy of Sciences and were planned to study the relation of quality and quantity of illumination to efficiency in industry.

The first experiments were planned to study the relations of levels of illumination to levels of worker output. Production rose as the amount of light was increased for an experimental group. However, the output of a control group also went up, even through no increase in the amount of illumination was provided. Furthermore, when the level of illumination provided to the experimental group was decreased to a level below that furnished for the control group, output continued to rise, as did that of the control group. These results suggested that modifications in illumination, with resulting changes in levels of fatigue experienced by the operators, were not responsible for the observed variations in production. As a result, research was extended to an examination of the effects of other conditions of work.

An extensive interview program was developed and a number of other experiments were conducted. Some of the more important experiments were the illuminating, rest pause, fatigue, and monotony experiments.

The Hawthorne researchers, according to Miller and Form (50), discovered "something which increased output no matter what was done about physical conditions." This something, they said, was attitude. In explanation for this conclusion regarding attitude, Miller and Form

(50) are quoted as follows:

> Workers are not governed primarily by economic motives. Underneath the stop watches and bonus plans of the efficiency experts, the worker is driven by a desperate inner urge to find an environment where he can take root, where he belongs and has a function; where he sees the purpose of his work and feels important in achieving it.

Roethlisberger and Dickson (41) sum up the findings of Hawthorne as follows:

> Every item and event in the industrial environment becomes an object of a system of sentiments. According to this way of looking at things; material goods, physical events, wages, hours of work, etc.; cannot be treated as things in themselves. Instead they must be interpreted as carriers of social value ... When social conditions of work are such as to make it difficult for the employee to identify his task with a socially meaningful function, he is liable to obsessive response and diminished capacity for work.

Taylor and Gilbreth and other early advocates of motion and time study and scientific management emphasized the necessity for satisfied workers and for good employer-employee relationships. The Hawthorne studies, however, emphasized the nature of social sentiments and feelings of industrial workers and of the routine patterns of interaction in the work group. The Hawthorne studies lead to the conclusion that other complicated factors in addition to good wages and good working conditions are involved in influencing a worker to produce at a faster rate. They tend to indicate that almost any device or technique with which the worker is associated could have an effect on his rate of output.

Penuela

Penuela (51) performed a study very similar to this one. His experiment (52) was designed to ascertain the influence of a time study analyst on the workers engaged in an industrial operation. From the results he concluded (53) that the times for job performance, taken by a time study analyst and registered by a concealed camera, differ significantly from those taken by the camera when the time study analyst is not present.

Penuela (54) lists four main classes of variations influencing the quality performance and production rate of workers: "namely, the mechanical, the sociological, the physiological, and the psychological."

Quoting from Penuela (55):

> No one of these variables can be considered independent, and, on the contrary, there exists a complex interrelationship. The experiment should, therefore, be restricted to the evaluation of the total effect that results from the conjugation of these variables, without any attempt to identify them separately. However, if a certain degree of homogeneity is attained, namely, by selecting workers of approximately the same social level, the same economic state, the same sex, age and experience, the same background, qualifications and emotional stability, and significant variation in their performances - under study and not under study - would necessarily reflect the effect introduced by the presence of the time study analyst regardless of the complexity of the factors creating such effect.

Similar assumptions were made for this study and the selection of workers was accomplished in approximately the same fashion. The main difference between this experiment and Penuela's was the use of a closed-circuit television system instead of a time study analyst. The introduction of the closed-circuit television system was the independent variable in this study and the problem consisted of determining its effect on the rate of output.

CHAPTER III

EQUIPMENT SELECTION AND INSTALLATION

The television system consisted of a camera mounted on a tripod in the work area, and a monitor located on a table in the general foreman's office. They were connected by approximately 100 feet of coaxial cable. Both the camera and the monitor were wired so that separate connections to the 110 volt, 60 cycle, alternating current, power supply were possible.

Specifications of the television camera and monitor are as follows:

	Camera	Monitor
Make	Dage	Miratel
Model	70 - B	K - 21M
Volts	105 - 125	105 - 125
Current	60 Cycle - AC	60 Cycle - AC
Watts Input	45	150
Size	7 5/8" x 5 15/16" x 11 13/16"	21" Tube
Volts (Peak to peak)	.5 to 1.0 output	.5 to 1.5 input
Horiz. Res.	600 Lines	600 Lines

The television equipment was used for less than eight hours but gave a very satisfactory picture during this period. No special adjustments were required either to set-up or to operate.

A time-lapse memomotion camera, type Keystone Criterion, 16 mm, Model A-19 was used to record all readings of rate of output. This camera had been modified by the addition of a synchronous motor with the following characteristics:

Volts	105 - 125
Current	60 Cycle AC
Watts	7.5
R.P.M.	100
Torque	12 in. oz.
Capacitor	.85 MFD
Duty	Continuous

The motor enabled the camera to take memomotion pictures at the rate of 100 frames per minute.

Kodak Tri-X reversal film was used because of the high (ASA 200) speed rating and the fact that the regular factory incandescent illumination, plus light from the outside windows, was not supplemented.

No difficulties resulting from faulty camera operation were encountered and pictures were obtained, as programmed, during the two four-week periods. Pictures of the camera are included, along with pictures of supporting equipment, as Figure 3.

The camera was turned on and off for two and one-half minute intervals. These intervals were programmed to occur four times a day (10:00 AM, 11:20 AM, 1:00 PM, and 4:00 PM) on Monday, Tuesday, and Wednesday of each week; during the experimental operation. The device used to control the camera motor was an electric timer. The timer clock was connected to a circuit that was normally turned off at the end of each shift. Characteristics of the timer are as follows:

Make	Zenith
Model	P 2.5 - 12 P 815
Serial	F 6460
Capacity	6 A - 115VAC 3 A - 230VAC
Motor	115VAC, 60 Cycle

As can be seen in Figure 3, the camera and timer were mounted in a cabinet. This cabinet was painted black and had two "mirrors" mounted on each of two of its vertical sides. One of these "mirrors" was made of transparent mirror glass. This glass looks like a mirror when no light is behind it but is actually transparent when the objects on the reverse side from the viewer are illuminated. The camera took satisfactory pictures through this glass. The box was painted black on the inside, and was fitted to exclude all light from the camera section. All shining parts of the camera were also covered with black tape to prevent reflections through the transparent mirror glass.

In addition to the camera and timer, a vibration meter was installed in the lower section of the cabinet, as shown in Figure 3. The cabinet was installed in full view of anyone in the general area of the workers being observed. The few people who asked were told that the box was installed to check vibration.

The use of a concealed camera may be considered by some people to be improper. However, if it is used only for scientific observation of rate of output, it appears to correspond to other accepted techniques of observing people.

Chapanis (56) makes the following statement: "It is hard for people to observe people: insofar as possible, the data of human experiments should come out in an objective permanent record which can be studied and gone over later."

During the Hawthorne Studies (41) changes were made in lighting conditions and resulting changes in worker output were measured with and without the workers' knowledge.

Various types of written and oral tests are given to people to determine their mental abilities, technical knowledge, social adaptability, or other characteristics. These could be part of an evaluation that would be comparable to a concealed camera. Scott et al (57) discuss tests given to Army recruits. These recruits were not always given the results and sometimes were rated without their knowledge. Measurements of aptitudes are also discussed by Scott et al, (58), as are various means of worker evaluation (59).

Chapanis (60) describes a method of monitoring long distance operators by the Bell Telephone Company. This, he says, is used in the telephone centers of most large cities. It is a means of listening to the operator place calls and determining if she has performed accurately.

McFarland and Mosely (61) describe procedures for detecting accident repeaters in truck drivers. One of these methods consists of the examination of motor vehicle records. In research of this type the details of personal records of traffic offenses are freely used without the knowledge of the people involved. They also describe the use of social service records (62) to investigate personal problem histories.

Since it is somewhat normal for research workers to evaluate people without these people knowing about it, a concealed camera used only for observing rate of output does not appear to be unethical or improper. When the intent of the observer is to use the observations only for scientific research there should be little objection to the use of a concealed memomotion camera. Care must be exercised in handling personal data concerning people, but this is the obligation of the scientist and should not prevent the use of this effective means of obtaining unbiased information.

A tape recorder was used to record discussions that took place in connection with the installation and removal of the television equipment. It had the following specifications and description:

Make	Revere
Model	T-1100
Volts	105 - 120
Current	60 Cycle - AC
Watts	90
Size	9½" x 14" x 13½"
Weight	27 pounds
Frequency Response	$\pm$3 db 85 - 7000 cps at 3 3/4 ips $\pm$3 db 75 - 12,000 cps at 7½ ips

A plan view of the installation at the plant is included as Figure 4. As can be seen, the arrangement provided a satisfactory method of observing the workers. Since the camera viewed all three workers simultaneously, a minimum amount of film was necessary.

The data were recorded by means of a systematic inspection of the films and is included as Tables 1 through 12. The film analysis was made with a Bell and Howell Motion and Time Study Projector, model XD, Design No. 57, equipped with a frame counter and heat filter. The accuracy in the reading allowed by the frame counter is plus or minus one-quarter frame. The projector operates from 105 - 125 volts, AC, 60 cycle current. It has a 750 watt bulb, a variable speed motor, and a hand crank for moving the film.

CHAPTER IV

PROCEDURE

In designing the experimental procedure, certain requirements were considered. These were important to the control of the experiment and will be briefly explained.

The experimental and control operations should be stable during the observation period with the same products, methods, and workers. Tasks should permit accurate measurement and should be repetitive. The speed of the operations should be wholly controlled by the workers. The memomotion camera should be capable of observing cycles of each work operation.

The workers involved should have approximately the same backgrounds, experience, and skill levels. They should have approximately the same training, job knowledge, output capabilities, and pay rate. The group of workers should be small and congenial (or at least cooperative). Management and union should be friendly and cooperative.

The products should be of such a nature that assembly cycle times would be relatively short (to conserve film), relatively simple (to avoid learning or re-learning problems), and of such a nature that they could be easily observed.

With the above requirements in mind, a local Atlanta, Georgia, plant was selected. The plant employs a total of approximately 200 people, about two-thirds male and one-third female.

Two products were selected; one assembled by one worker, and the other by two. The product assembled by two workers is partially assembled by the first and is then passed on to the second for final assembly. The assembly of the first product by one worker was selected as the experimental operation, for observation by the television camera, and the two-worker assembly operations were the controls. The control operations will be referred to as control and second control. Second control was the sub-assembly and control was the final assembly. The operations were stable during the observation period and the speed was wholly controlled by the workers. The cycle time for each of the three operations could be observed by the memomotion camera. The products selected were relatively simple, having cycle times ranging from approximately two-tenths to a maximum of one-half minutes. An operation chart for each of the operations is included as Figures 5, 6, and 7.

Arrangements with the plant were made through the plant manager, the general foreman, and the floorlady in charge of the operations to be observed. Conversations with others at the plant were held to a minimum. Conferences with the three officials were usually made when either few or no others were present.

The workers involved are part of a group of approximately 50 women making and assembling small electrical parts and assemblies and using them in larger electrical products. Many of the women in this group are rotated from one job to another, depending on daily needs of the company and characteristics of the individuals. Two weeks prior to the start of the observations, three workers were selected by the general foreman and floorlady. The plant manager, general foreman, and floorlady were consulted regarding their opinion of the workers. Each worker was evaluated from the standpoints of being average (or slightly above) in production output, not anti-management, not unusually excitable, and steady. These particular characteristics were desired in order to have regular, representative workers and to eliminate, or at least reduce, the possibility of a disruption of the experiment. Additional characteristics of these workers are included as Figures 8, 9, and 10.

On the week-end prior to the assignment of the three operators, the black cabinet containing the vibration meter and timer, was installed at the plant. The memomotion camera was omitted for a two-week period to allow the workers to become accustomed to the cabinet and to allow them to look inside, if they desired. The transparent mirror glass was covered, during this period, to prevent detection. The timer was completely connected so that the camera could be simply plugged into a multiple receptacle, inside the box, when it was installed. The box was left open for an undetermined period. The floorlady was instructed to tell questioners that the apparatus was a vibration detector.

Following the two-week familiarization and stabilization period, the actual observations were begun. The plant manager, general foreman, and floorlady were all in agreement that the work had stabilized and that the black cabinet had been accepted as a vibration tester.

On Saturday, August 4, 1962, the memomotion camera was installed and the timer was set to cause the camera to operate for two and one-half minute periods at 10:00 AM, 11:20 AM, 1:00 PM, and 4:00 PM. The light meter read .6 on the Weston Scale, the distance of the camera was set for 25 feet, the f setting was 4.0, and Kodak Tri-X reversal film was installed. One employee was working approximately 25 feet from the black cabinet while the camera was being installed. In the opinion of the general foreman and the writer, this worker did not know, nor care, what was being done.

The first week's film was unsatisfactory because of the incorrect location of the camera in the cabinet. The film was changed on each succeeding Saturday for four weeks. The swing shift could not be relied upon to keep the light circuit controlling the camera turned off. In fact, they were more likely to turn it on than to leave it off. This would cause the camera to run at 10:00 PM, 11:20 PM, and sometimes at 1:00 AM. Because of this uncertainty, and in order not to shorten the two and one-half minute observation cycle, and at the same time confine film consumption to one 100 foot roll per week; readings for Monday, Tuesday, and usually part of Wednesday were considered acceptable. The plant did not work on Labor Day, September 4, 1962, so the film for that week was advanced one day.

Following the first four weeks of satisfactory observations, there were no readings for approximately seven weeks. During this period the film was analyzed to be certain that sufficient information was available for statistical testing. Also, during this period, weekly discussions were held with the plant executives. Three postponements were due to the desire to make the installation when a minimum amount of worker unrest was indicated.

Arrangements were made for installation of the television camera on Monday, October 29, 1962. The installation procedure was designed to follow as closely as possible that of other new equipment at this plant.

For this reason, it was taken to the plant on Saturday, October 27, 1962 and the maintenance workers were given instructions regarding installation.

The original experimental design included provisions for thoroughly checking with the union executives before installation of the television equipment. This idea was abandoned in favor of using techniques closely approximating those used at this plant for installing other types of equipment. These techniques were to install the equipment and then instruct the affected workers regarding its operation.

The television equipment was operated by the maintenance personnel, for a short period Monday morning, prior to the time the general foreman or plant manager arrived. When the general foreman arrived, the experimental worker was instructed and advised concerning the television camera. A tape recording was made of this conversation, without the knowledge of the experimental worker. A transcript of this conversation is included as Figure 11. The television camera was turned off between 1:00 PM and 4:00 PM on the same day it was installed, and was removed from the plant on the following Saturday, November 4, 1962. Discussions regarding the television installation were also recorded. These include talks with the plant personnel manager, the union stewardess, the plant manager, general foreman, and the writer. The personnel manager and union stewardess were not aware of the recordings. Transcripts of these conversations are included as Figure 12.

The final four-week period of observation began on the day the television system was installed, October 29, 1962. It continued through Wednesday, November 21, 1962. Graphic representations of the observation periods for each operator are included as Figures 13, 14, and 15.

The data were obtained from the memomotion film by counting the number of frames per work cycle. The cycles of each operation could be determined from the time of gripping the air-operated screwdrivers, since, for each operation, this gripping occurred only one time.

Following and during the accumulation of data, circumstances surrounding the experiment were discussed with the plant manager and general foreman. Pertinent union activities, grievances, layoffs, and attendence were among the topics covered.

A tape recording was made of a discussion between the plant manager, the general foreman, and the writer. This recording occurred during the week following removal of the television system. It contains the details of the removal and the employer-employee-union relationships existing before, during, and after the television functioning. The contents of this tape are not included in the thesis.

CHAPTER V

DISCUSSION OF DATA

The data were summarized and arranged in tabular form for each of the three operators: experimental, control, and second control; as shown by Tables 1 through 12. The readings are presented, for each of the three operators, divided into the four periods: (1) before television installation, (2) during television functioning, (3) first or first and second week following television removal, and (4) third and fourth weeks following the television removal. The third period consists of two weeks for the experimental operator and one week for the other two operators. This difference was caused by the reassignment of the two control operators during the second week following removal of the television equipment.

The data were arranged by day of week, date, time, reading sequence number, film frames per reading (x), the square of the frames (x^2), and remarks. The reading sequence number is continuous through each period. Remarks indicate reasons for omitting a reading in the calculations and an asterick (*) following the reading indicates such an omission. The acceptable number of readings (n), their sum, the mean ($\bar{x}$), the variance (s^2), and the standard deviation (s) are calculated at the end of each table.

As indicated in Chapter III, the accuracy of the film analysis projector was plus or minus one-quarter frame. The means ranged from 25.19, for the control operator during the fourth period, to 70.83 for the experimental operator during the third period. This allows the maximum possible percentage error to range from .98 to .36, and it was omitted from the calculations.

The basic data are also summarized graphically by Figures 16, 17, and 18. These graphs indicate the two standard deviation range for results of each operator, by period of activity.

The design and results of the experiment did not allow for uniform sample sizes. This is especially true for the period during actual functioning of the television system, since it was removed after operating for less than eight hours. Additionally, the readings were taken in an operating plant and it was impossible to guarantee uniform activity at all three jobs during each mechanically-timed observation.

Graphical tests of normality, by period, are shown by Figures 19 through 30. These graphs are plots of the cumulative frequencies by groups of readings. They are plotted on normal probability paper and a straight line indicates normality. This technique is discussed by Duncan (63).

When the graphs did not appear to indicate normality, the data were further checked using the chi square test of goodness of fit. These tests are shown as Figures 31 through 40 and the technique is also explained by Duncan (64).

Checks for randomness, for each period and by operator, were also made. Two types of tests were made: (1) distribution of the total number of runs, and (2) distribution of the lengths of runs. For the first type, the number of runs above and below the median were determined and compared to tables of allowable values. When the computed value was greater than the theoretical value at a 5 percent level of significance, the data were assumed to be random. For the second type of comparison (length of runs) the computed maximum length was compared to the 5 percent value in the tables. Randomness was indicated by the table value being the larger. Tests of this type are described by Duncan (65) and are included as Figures 41 through 52.

For the data indicating a normal distribution, at the 5 percent level of significance, further tests for the equality of the variances (F) and means (t or t') were made. These compared the various combinations of work periods for each worker. In both types of tests the one-sided tests were used and equality was accepted or rejected based on a 5 percent level of significance. The t' test, for equality of means, was used when the variances were not found to be equal, based on the F test. The t test was used when the variances were found to be equal. These tests are described by Bowker and Lieberman (66) and are included as Figures 53 through 62.

CHAPTER VI

RESULTS AND CONCLUSIONS

This chapter is primarily devoted to discussions of the quantitative results. The premature removal of the television equipment, and the resulting limited sample sizes, cause the results to be questionable.

The most significant result was the forced removal of the television system. This was caused by worker objections, through the union, after less than eight hours operation.

Generally, the quantitative results tend to follow previous work by Penuela (2) concerning the effect of the presence of a time study analyst. They also tend to follow some of the results of the Hawthorne studies, namely, that output of nearby workers was also affected.

In considering these results, the four periods will be referred to by number; one, two, three, and four. These periods have been defined previously in the discussion of the data and are shown on the results summaries of Tables 13, 14, and 15. Additionally, whenever significance level is mentioned, the 5 percent level is intended.

As can be seen in Table 13, the distributions of outputs of the experimental operator were normal, random, and had significantly different variances and means between period one and period two. Between periods one and three the means were significantly different but the variances were not. Output during period one was not significantly different from period four, from the standpoints of either variances or means. Between periods two and three, both the variances and means were significantly different. Between two and four the means were different but not the variances. Finally, between periods three and four, the means were different but not the variances.

The results concerning the output distributions of the experimental operator indicate that the television installation did significantly affect the rate of output. The output, based on these tests, returned to the same pattern during the third and fourth weeks following removal of the television as that prevailing in the four-week period before the installation. The analysis of the periods during television functioning, and for the first and second weeks following, indicates that the television installation effect was residual. Based on these results, and for this situation, the null hypothesis of this thesis is rejected. This null hypothesis states that the rate of output of industrial workers, during observation of that output by a closed-circuit television camera, with the monitor in the general foreman's office, does not differ significantly from the rate of output of the same workers when the television camera is not present.

Before considering the results of the statistical tests concerning the distribution of output data from the two control operations, some non-quantitative results will be discussed.

The second control operator was replaced, due to absence, for the last week of period one. This absence was because of a family problem, as documented by Figure 10. The second control operator produced a sub-assembly that was made into a complete assembly by the control operator. The data from both the control and second control operators indicates non-normality during period one. Period one includes the period of absence of the second control operator.

The other non-quantitative result that should be considered concerns the control operation. The assembly produced by the control operator sometimes included the location of an additional screw in a non-threaded hole, and at times did not include this screw. The availability of screws was the determining factor. During the experiment, the writer was unaware of this condition and no record was kept concerning this additional operation.

Table 14 indicates that the distribution of the data from periods one and four for the central operator was not normal. Since periods two and three indicated normality, it may be assumed that periods one and four differ significantly from periods two and three. Data of all periods but period one indicate randomness. The variances and means of data from periods two and three are not significantly different. No comparison of periods one and four was attempted due to the unknown effect of the second control operator's absence during period one.

Based on these tests, data of periods two and three from the control operator's output appear to be from the same population. Data from periods one and four do not appear to be from this population. This significant difference in output, during the functioning and for the first and second weeks following removal of the television equipment, indicates that the control operator's output rate was significantly increased by the television installation and following events. The question of the possibility of an additional operation, plus the fact that the control operator's rate of output could be affected by the second control operator, tends to cause this conclusion to be subject to question.

The analysis of the data from the output of the second control operator (Table 15), for the first time period, indicates significant non-normality and non-randomness. Since the data of the first time period are not normally distributed, they are significantly different from those of periods two, three, and four. Period two versus three indicates significant differences in both variances and means. Comparisons of data between periods two and four indicate no significant difference between either variances or means. A comparison of period three versus period four indicates significant difference between both variances and means.

From this analysis, it may be concluded that influences, not herein documented, were present during the period before installation of the television equipment. This is deduced from the tests that indicate period one was significantly different from two and three but that period two was not significantly different from period four. There is a possibility that the undocumented influences were connected with the second control operator's absence.

The significant difference between the period during the first week following removal of the television equipment and the period during the third and fourth weeks following removal could indicate that the rate of output of this operator might also have been affected by the events following the television installation. The fact that there was no significant difference between the period during television functioning and the period during the third and fourth weeks following television removal could indicate that there was no effect during the actual operation.

The output data are not sufficient to generalize and additional experiments are necessary to obtain general conclusions.

Original arrangements were to discuss the results with workers and union executives. Due to later events, these plans had to be abandoned.

Certain data discussed in this thesis have not been included. This information is necessary for complete documentation and should normally be available to anyone sincerely wanting to replicate the experiment. Because of the circumstances of the television removal, this information is not generally available and has been disposed of in accordance with a procedure approved by the Director of the School of Industrial Engineering at the Georgia Institute of Technology. A discription of this material is contained in Figure 63.

CHAPTER VII

RECOMMENDATIONS

Additional experiments with similar hypotheses are suggested. These include the following:

1. Comparisons of reactions in situations of varying degrees of employee organization.

2. Advance agreements between management and union executives regarding experimental design.

3. Interviews with workers and union personnel after the experiment.

4. Products that are more complicated.

5. Other types of jobs, such as assembly line or construction.

6. Other industries.

7. Use of a duplicate monitor that employees can also watch, as suggested by Rochette (6).

8. Methods other than the memomotion camera for obtaining output rates.

APPENDIX

Table 1. Summary of Readings -- Experimental Before Television Installation

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	8/13	11:00 AM	1	12*		Assembly
			2	156*		Arrangements
		2:00 PM	3	63	3969	
			4	61	3721	
			5	60	3600	
Tues.	8/14	11:00 AM	6	136*		Arrangements
			7	66	4356	
		2:00 PM	8	28*		Assembly
			9	80	6400	
Wed.	8/15	11:00 AM	10	60	3600	
			11	63	3969	
			12	75	5625	
		2:00 PM	13	58*		In process
			14	67	4489	
			15	82	6724	
Mon.	8/20	10:00 AM	16	57*		Two visitors
			17	22*		Two visitors
			18	52*		Two visitors
		11:20 AM	19	54	2916	
			20	60	3600	
			21	61	3721	
			22	64	4096	

Table 1. Summary of Readings -- Experimental Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
		1:00 PM	23	77	5929	
			24	64	4069	
Mon.	8/20	1:00 PM	25	66	4356	
		4:00 PM	26	81	6561	
			27	77	5929	
Tues.	8/21	10:00 AM	28	77	5929	
			29	74	5476	
		1:00 PM	30	97	9409	
			31	61	3721	
Wed.	8/22	10:00 AM	32	55	3025	
			33	51	2601	
			34	56	3136	
Mon.	8/27	11:20 AM	35	54	2916	
			36	58	3364	
			37	59	3481	
		1:00 PM	38	68	4624	
			39	64	4096	
		4:00 PM	40	63	3969	
			41	57	3249	
			42	77	5929	
Tues.	8/28	1:00 PM	43	71	5041	

Table 1. Summary of Readings -- Experimental Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			44	55	3025	
		4:00 PM	45	72	5184	
			46	70	4900	
			47	68	4624	
Wed.	8/29	11:20 AM	48	62	3844	
			49	64	4096	
			50	59	3481	
		1:00 PM	51	61	3721	
			52	62	3844	
Wed.	8/29	1:00 PM	53	60	3600	
Tues.	9/4	10:00 AM	54	68	4624	
			55	65	4225	
			56	68	4624	
		1:00 PM	57	77	5929	
			58	66	4356	
			59	61	3721	
		4:00 PM	60	66	4356	
			61	62	3844	
			62	16*		View obscure
Wed.	9/5	10:00 AM	63	10*		View obscure
			64	89*		Scene changed

Table 1. Summary of Readings -- Experimental Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			65	59	3481	
		11:20 AM	66	75	5625	
			67	68	4624	
			68	62	3844	
		1:00 PM	69	79*		Visitor
			70	58*		Visitor
			71	63*		Visitor
		4:00 PM	72	64	4096	
			73	65	4225	
			74	66	4356	
Thurs.	9/6	10:00 AM	75	53	2809	
			76	58	3364	
			77	57	3249	
			78	58	3364	
			79	62	3844	
			80	63	3969	
			Totals	4299	284471	

* Indicates readings that are unacceptable.

Total acceptable readings, n = 66

Total value (frames) of acceptable readings = 4299

Mean, $\bar{x}$ = 4299/66 = 65.14

Table 1. Summary of Readings -- Experimental Before Television Installation

(Continued)

$$\text{Standard deviation, } s = \sqrt{\sum (x - \bar{x})^2/n - 1}$$

$$(x - \bar{x})^2 = \sum x^2 - (\sum x)^2/n$$

$$= 284{,}471 - (4299)^2/66 = 4450.02$$

$$s = \sqrt{4550.02/65 = 8.28}$$

Table 2. Summary of Readings -- Experimental During Television Functioning

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	10/29	11:20 AM	1	80*		Arranging
			2	63	3969	
			3	64	4096	
			4	57	3249	
			5	61	3721	
			6	58	3364	
			Totals	303	18399	

Total acceptable readings, n = 5

Total value of acceptable readings = 303

Mean, $\bar{x} = 303/5 = 60.60$

$\sum(x - \bar{x})^2 = 18399 - (303)^2/5 = 37.20$

Standard deviation, $s = \sqrt{37.20/4} = 3.05$

Table 3. Summary of Readings -- Experimental During First and Second Weeks Following Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	10/30	1:00 PM	1	67	4489	
			2	82	6724	
			3	77	5929	
		4:00 PM	4	64	4096	
			5	66	4356	
			6	60	3600	
Wed.	10/31	10:00 AM	7	75	5625	
		11:20 AM	8	83	6889	
			9	74	5476	
			10	68	4624	
Mon.	11/5	10:00 AM	11	55	3025	
			12	84	7056	
			13	57	3249	
		11:20 AM	14	67	4489	
			15	70	4900	
			16	74	5476	
Mon.						
	11/5	1:00 PM	17	77	5929	
			18	77	5929	
			19	71	5041	
Tues.	11/6	10:00 AM	20	63*		Scene change
			21	80	6400	

Table 3. Summary of Readings -- Experimental During First and Second Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			22	79	6241	
		11:20 AM	23	61	3721	
			24	69	4761	
			25	63	3969	
		1:00 PM	26	31*		Film obscure
			27	63*		Film obscure
			28	69*		Film obscure
			29	38*		Film obscure
			Totals	1700	121994	

Total acceptable readings, n = 24

Total value of acceptable readings = 1700

Mean, $\bar{x} = 1700/24 = 70.83$

$\sum(x - \bar{x})^2 = 121994 - (1700)^2/24 = 1577.33$

Standard deviation, $s = \sqrt{1577.33/23} = 8.28$

Table 4. Summary of Readings -- Experimental During Third and Fourth Weeks Following Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	11/13	10:00 AM	1	68	4624	
			2	61	3721	
		11:20 AM	3	70	4900	
			4	62	3844	
			5	65	4225	
		1:00 PM	6	56	3136	
			7	60	3600	
			8	82*		Equip. adj.
		4:00 PM	9	66*		Equip. adj.
			10	64	4096	
			11	63	3969	
Wed.	11/14	10:00 AM	12	55	3025	
			13	54	2916	
			14	59	3481	
			15	67	4489	
			16	72	5184	
			17	76	5776	
		1:00 PM	18	79	6241	
		4:00 PM	19	87*		View obscure
			20	64*		View obscure
Mon.	11/19	10:00 AM	21	58	3364	
		1:00 PM	22	59	3481	

Table 4. Summary of Readings -- Experimental During Third and Fourth Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	53	2809	
			24	53	2809	
		4:00 PM	25	73	5329	
			26	61	3721	
			27	62	3844	
Tues.	11/20	10:00 AM	28	63	3969	
			29	60	3600	
			30	62	3844	
		11:20 AM	31	76*		Dark
			32	86*		Dark
			33	57*		Dark
		1:00 PM	34	76*		Dark
			35	72*		Dark
			36	80*		Dark
		4:00 PM	37	61	3721	
			38	61	3721	
			39	62	3844	
Wed.	11/21	10:00 AM	40	84*		Dark
			41	62	3844	
			42	66	4356	
		11:20 AM	43	24*		Dark

Table 4. Summary of Readings -- Experimental During Third and Fourth Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			44	69	4761	
		1:00 PM	45	83*		Arranging
			46	73	5329	
			Totals	2089	133573	

Total acceptable readings, n = 33

Total value of acceptable readings = 2089

Mean, $\bar{x} = 2089/33 = 63.30$

$\sum(x - \bar{x})^2 = 133573 - (2089)^2/33 = 1333.01$

Standard deviation, $s = \sqrt{1333.01/32} = 6.45$

Table 5. Summary of Readings -- Control Before Television Equipment Installation

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	8/13	11:00 AM	1	27	729	
			2	35	1225	
			3	40	1600	
			4	21	441	
			5	30	900	
			6	26	676	
Tues.	8/14	2:00 PM	7	34	1156	
			8	46	2116	
			9	32	1024	
			10	41*		View obscure
			11	8*		View obscure
			12	18*		View obscure
Wed.	8/15	11:00 AM	13	17*		View obscure
			14	15*		View obscure
			15	19*		View obscure
			16	21	441	
			17	16	256	
			18	16	256	
			19	16	256	
			20	16	256	
			21	19	361	
			22	16	256	

Table 5. Summary of Readings -- Control Before Television Equipment Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	21	441	
Wed.	8/15	11:00 AM	24	19	361	
			25	15	225	
Mon.	8/20	1:00 PM	26	35	1225	
			27	37	1369	
			28	32	1024	
			29	47	2209	
			30	39	1521	
		4:00 PM	31	33	1089	
			32	31	961	
			33	32	1024	
			34	35	1225	
			35	33	1089	
			36	28	784	
Wed.	8/22	11:20 AM	37	22*		View obscure
			38	25*		View obscure
			39	20*		View obscure
			40	24*		View obscure
			41	25*		View obscure
			42	24*		View obscure
			43	27*		View obscure

Table 5. Summary of Readings -- Control Before Television Equipment Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			44	28*		View obscure
			45	22*		View obscure
		1:00 PM	46	42*		View obscure
Mon.	8/27	1:00 PM	47	25*		In process
			48	46	2116	
			49	32	1024	
Mon.	8/27	1:00 PM	50	31	961	
			51	34	1156	
			52	40	1600	
			53	33	1089	
		4:00 PM	54	39	1521	
			55	42	1764	
			56	37	1369	
			57	30	900	
			58	34	1156	
			59	34	1156	
Tues.	8/28	1:00 PM	60	28	784	
			61	35	1225	
Wed.	8/29	1:00 PM	62	30	900	
			63	32	1024	
Tues.	9/4	10:00 AM	64	37	1369	

Table 5. Summary of Readings -- Control Before Television Equipment Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			65	29	841	
			66	31	961	
			67	29	841	
		11:20 AM	68	67*		Visitor
			69	69*		Visitor
			70	59*		Visitor
		1:00 PM	71	36	1296	
			72	39	1521	
			73	36	1296	
			74	37	1369	
			75	39	1521	
			76	38	1444	
Wed.	9/5	11:20 AM	77	34	1156	
			78	39	1521	
			79	40	1600	
			80	41	1681	
			81	37	1369	
			82	36	1296	
		1:00 PM	83	41	1681	
			84	34	1156	
			85	42	1764	

Table 5. Summary of Readings -- Control Before Television Equipment Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
		4:00 PM	86	32	1024	
			87	47	2209	
			88	43	1849	
			89	33	1089	
			90	39	1521	
Thurs.	9/6	10:00 AM	91	29	841	
			92	34	1156	
			93	34	1156	
			94	34	1156	
			95	33	1089	
			96	32	1024	
			97	34	1156	
			98	29	841	
			99	33	1089	
			100	33	1089	
			101	31	961	
			Totals	2650	91174	

Total acceptable readings, n = 81

Total value of acceptable readings = 2650

Mean, $\bar{x} = 2650/81 = 32.72$

$\sum(x - \bar{x})^2 = 91174 - (2650)^2/81 = 4476.50$

Standard deviation, $s = \sqrt{4476.50/80} = 7.48$

Table 6. Summary of Readings -- Control During Television Functioning

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	10/29	10:00 AM	1	24	576	
			2	27	729	
			3	38	1444	
			4	28	784	
			5	22	484	
			6	21	441	
			7	21	441	
			8	21	441	
		1:00 PM	9	34	1156	
			10	33	1089	
			11	35	1225	
			12	92*		Visitor
			13	9*		Visitor
			Totals	304	8810	

Total acceptable readings, $n = 11$

Total value of acceptable readings = 2650

Mean, $\bar{x} = 304/11 = 27.63$

$$\sum(x - \bar{x})^2 = 8810 - (304)^2/11 = 408.50$$

Standard deviation, $s = \sqrt{408.50/10} = 6.39$

Table 7. Summary of Readings -- Control During First Week Following Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	10/30	10:00 AM	1	28	784	
			2	21*		Talking
			3	66*		Talking
		1:00 PM	4	11*		Talking
			5	21	441	
			6	19	361	
			7	16	256	
			8	24	576	
			9	22	484	
			10	25	625	
			11	30	900	
		4:00 PM	12	21	441	
			13	22	484	
			14	21	441	
			15	35	1225	
			16	23	529	
			17	26	676	
			18	28	784	
Wed.	10/31	10:00 AM	19	29	841	
		1:00 PM	20	27	729	
			21	36	1296	
			22	27	729	

Table 7. Summary of Readings -- Control During First Week Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	25	625	
			Totals	505	13227	

Total acceptable readings, n = 20

Total value of acceptable readings = 505

Mean, $\bar{x} = 505/20 = 25.25$

$\sum(x - \bar{x})^2 = 13227 - (505)^2/20 = 475.75$

Standard deviation, $s = \sqrt{475.75/19} = 5.00$

Table 8. Summary of Readings -- Control During Third and Fourth Weeks After Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	11/13	11:20 AM	1	19	361	
			2	55*		Arranging
			3	38	1444	
			4	25	625	
			5	39	1521	
		1:00 PM	6	11*		View obscure
			7	22	484	
			8	21	441	
			9	22	484	
			10	24	576	
			11	60*		Talking
			12	22	484	
			13	26	676	
			14	28	784	
		4:00 PM	15	24*		Scene change
			16	31	961	
			17	22	484	
			18	24	576	
			19	24	576	
			20	21	441	
			21	20	400	
			22	23	529	

Table 8. Summary of Readings -- Control During Third and Fourth Weeks After Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	27	729	
Wed.	11/14	10:00 AM	24	27	729	
			25	49*		Left area
			26	24	576	
		11:20 AM	27	28	784	
			28	22	484	
			29	26	676	
			30	23	529	
			31	22	484	
			32	23	529	
			33	26	676	
			34	22	484	
			35	22	484	
			36	24	576	
		1:00 PM	37	29	841	
			38	26	676	
			39	31	961	
			40	24	576	
			41	24	576	
			42	24	576	
			43	30	900	

Table 8. Summary of Readings -- Control During Third and Fourth Weeks After Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	11/19	10:00 AM	44	31*		View obscure
			45	23*		View obscure
			46	24*		View obscure
			47	27*		View obscure
		11:20 AM	48	25	625	
			49	23	529	
			50	23	529	
			51	22	484	
			52	28	784	
			53	22	484	
			54	40*		Talking
		1:00 PM	55	25	625	
			56	28	784	
			57	22	484	
			58	26	676	
			59	26	676	
			60	26	676	
			61	22	484	
			62	26	676	
		4:00 PM	63	32*		View obscure
			64	23	529	

Table 8. Summary of Readings -- Control During Third and Fourth Weeks After Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			65	26	676	
			66	34	1156	
			67	28	784	
			Totals	1410	36354	

Total acceptable readings, n = 56

Total value of acceptable readings = 1410

Mean, $\bar{x}$ = 1410/56 = 25.19

$\sum(x - \bar{x})^2 = 36354 - (1410)^2/56 = 852.30$

Standard deviation, $s = \sqrt{852.30/55} = 3.94$

Table 9. Summary of Readings -- Second Control Before Television Installation

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	8/13	11:00 AM	1	36	1296	
			2	29	841	
			3	63	3969	
			4	21	441	
			5	27	729	
			6	23	529	
Tues.	8/14	2:00 PM	7	16	256	
			8	38*		Arranging
			9	25	625	
			10	29	841	
			11	25	625	
			12	29	841	
			13	19*		Talking
			14	36*		Talking
Mon.	8/20	11:20 AM	15	28	784	
			16	24	576	
			17	26	676	
			18	25	625	
			19	27	729	
			20	57*		Arranging
			21	23	529	
			22	19	361	

Table 9. Summary of Readings -- Second Control Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
		1:00 PM	23	20	400	
			24	18	324	
			25	21	441	
			26	32	1024	
			27	19	361	
			28	33*		Arranging
			29	27	729	
			30	30	900	
			31	19	361	
			32	19	361	
		4:00 PM	33	30	900	
			34	34*		Arranging
			35	26	676	
			36	33	1089	
			37	27	729	
			38	24	576	
			39	26	676	
Tues.	8/21	10:00 AM	40	27	729	
			41	29	841	
			42	116*		Arranging
			43	21	441	

Table 9. Summary of Readings -- Second Control Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			44	19	361	
			45	20	400	
		1:00 PM	46	6*		View obscure
			47	22	484	
			48	19	361	
			49	24	576	
			50	22	484	
			51	20	400	
			52	18	324	
			53	20	400	
Wed.	8/22	10:00 AM	54	22	484	
			55	19	361	
			56	21	441	
			57	20	400	
			58	24	576	
			59	18	324	
			60	20	400	
			61	23	529	
			62	19	361	
			63	18	324	
			64	18	324	

Table 9. Summary of Readings -- Second Control Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			65	16	256	
		11:20 AM	66	23	529	
			67	24	576	
			68	28	784	
			69	22	484	
			70	21	441	
			71	25	625	
			72	27*		Arranging
			73	25	625	
			74	21	441	
			75	31	961	
		1:00 PM	76	16	256	
			77	28	784	
			78	18	324	
			79	19	361	
Mon.	8/27	10:00 AM	80	52*		Arranging
		1:00 PM	81	24	576	
			82	27	729	
			83	31	961	
			84	27	729	
		4:00 PM	85	27	729	

Table 9. Summary of Readings -- Second Control Before Television Installation

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			86	30	900	
			87	32	1024	
			88	40	1600	
			89	34	1156	
			90	27	729	
Tues.	8/28	10:00 AM	91	36	1296	
			92	36	1296	
			93	46	2116	
			94	36	1296	
		1:00 PM	95	63*		Visitor
			96	39	1794	
		4:00 PM	97	20	400	
			98	48	2304	
			100	43*		Arranging
			101	23	529	
Wed.	8/29	1:00 PM	102	29	841	
			Totals	2305	64326	

Total acceptable readings, n = 90

Total value of acceptable readings = 2305

Mean, $\bar{x} = 2305/90 = 25.56$

$\sum(x - x)^2 = 64326 - (2305)^2/90 = 5292.40$

Standard deviation, $s = \sqrt{5292.40/89} = 7.71$

Table 10. Summary of Readings -- Second Control During Television Functioning

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Mon.	10/29	10:00 AM	1	26	676	
			2	28	784	
			3	44*		Arranging
			4	26	676	
			5	25	625	
			6	36	1296	
			7	29	841	
		1:00 PM	8	23	529	
			9	23	529	
			10	24	576	
			11	54*		Arranging
			12	26	676	
			13	28	784	
			14	23	529	
		4:00 PM	15	26	676	
			16	22	484	
			17	25	625	
			18	29	841	
			19	23	529	
			20	24	576	
			21	23	529	
			22	22	484	

Table 10. Summary of Readings -- Second Control During Television Functioning

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	27	729	
			Totals	538	13994	

Total acceptable readings, n = 21

Total value of acceptable readings = 538

Mean, $\bar{x} = 538/21 = 25.62$

$\sum(x - \bar{x})^2 = 13994 - (538)^2/21 = 211.06$

Standard deviation, $s = \sqrt{211.06/20} = 3.25$

Table 11. Summary of Readings -- Second Control During First Week Following Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	10/30	10:00 AM	1	28	784	
			2	36	1296	
			3	30	900	
			4	39	1521	
			5	33	1089	
			6	37	1369	
		1:00 PM	7	27	729	
			8	33	1089	
			9	31	961	
			10	27	729	
			11	25	625	
			12	23	529	
			13	25	625	
			14	24	576	
		4:00 PM	15	27	729	
			16	34	1156	
Wed.	10/31	1:00 PM	17	23	529	
			18	59*		Arranging
			19	24	576	
			20	27	729	
			Totals	553	16541	

Table 11. Summary of Readings -- Second Control During First Week Following Removal of Television Equipment

(Continued)

Total acceptable readings, $n = 19$

Total value of acceptable readings = 553

Mean, $\bar{x} = 553/19 = 29.11$

$\sum(x - x)^2 = 16541 - (553)^2/18 = 445.79$

Standard deviation, $s = \sqrt{445.79/17} = 4.98$

Table 12. Summary of Readings -- Second Control During Third and Fourth Weeks Following Removal of Television Equipment

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
Tues.	11/13	11:20 AM	1	31	961	
			2	36	1296	
			3	27	729	
			4	29	841	
			5	27	729	
			6	29	841	
			7	23	529	
			8	28	784	
		1:00 PM	9	50*		Looking up
			10	36*		Looking up
			11	26*		Looking up
			12	34*		Arranging
			13	26	676	
			14	30	900	
		4:00 PM	15	27	729	
			16	43*		Arranging
			17	25	625	
			18	27	729	
			19	30	900	
			20	29	841	
			21	29	841	
Wed.	11/14	10:00 AM	22	27	729	

Table 12. Summary of Readings -- Second Control During Third and Fourth Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			23	28	784	
			24	27	729	
		11:20 AM	25	25	625	
			26	25	625	
			27	25	625	
			28	25	625	
			29	23	529	
			30	39	1521	
			31	24	576	
			32	27	729	
			33	26	676	
		1:00 PM	34	27	729	
			35	25	625	
			36	32	1024	
			37	43*		Arranging
			38	25	625	
			39	27	729	
			40	28	784	
			41	22	484	
		4:00 PM	42	29	841	
Mon.	11/19	10:00 AM	43	23	529	

Table 12. Summary of Readings -- Second Control During Third and Fourth Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			44	22	484	
			45	23	529	
			46	24	576	
			47	22	484	
		11:20 AM	48	28	784	
			49	26	676	
		1:00 PM	50	26	676	
			51	26	676	
			52	24	576	
			53	42	1764	
			54	23	529	
			55	27	729	
			56	28	784	
		4:00 PM	57	23	529	
			58	27	729	
			59	27	729	
			60	27	729	
			61	32	1024	
			62	52*		Arranging
Tues.	11/20	11:20 AM	63	39*		Arranging
			64	30	900	

Table 12. Summary of Readings -- Second Control During Third and Fourth Weeks Following Removal of Television Equipment

(Continued)

Day	Date	Time	Reading No.	Frames x	x^2	Remarks
			65	29	841	
			66	29	841	
			67	28	784	
			68	26	676	
			69	23	529	
			70	25	625	
Wed.	11/21	11:20 AM	71	30	900	
			72	30	900	
			73	24	576	
			74	23	529	
			75	25	625	
			76	22	484	
			77	20	400	
			78	24	576	
			79	25	625	
			Totals	1902	51912	

Total acceptable readings, $n = 71$

Total value of acceptable readings = 1902

Mean, $\bar{x} = 1902/71 = 26.79$

$\sum(x - x)^2 = 51912 - (1902)^2/71 = 959.91$

Standard deviation, $s = \sqrt{959.91/70} = 3.70$

Table 13. Results -- Experimental Operation

Period Number	n	$\bar{x}$	s	Normal	Random
1	66	65.14	8.28	Yes	Yes
2	5	60.60	3.05	Yes	Yes
3	24	70.83	8.28	Yes	Yes
4	33	63.30	6.45	Yes	Yes

Equality of:

	Variances	Means
1 vs 2	No	No
vs 3	Yes	No
vs 4	Yes	Yes
2 vs 3	No	No
vs 4	Yes	No
3 vs 4	Yes	No

Table 14. Results -- Control Operation

Period Number	n	$\bar{x}$	s	Normal	Random
1	81	32.72	7.48	No	No
2	11	27.63	6.39	Yes	Yes
3	20	25.25	5.00	Yes	Yes
4	56	25.19	3.94	No	Yes

Equality of:

	Variances	Means
2 vs 3	Yes	Yes

Table 15. Results -- Second Control Operation

Period Number	n	$\bar{x}$	s	Normal	Random
1	90	25.56	7.71	No	No
2	21	25.62	3.25	Yes	Yes
3	19	29.11	4.98	Yes	Yes
4	71	26.79	3.70	Yes	Yes

Equality of:

	Variances	Means
2 vs 3	No	No
vs 4	Yes	Yes
3 vs 4	No	No

APPLICATION	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Advertising	•									•		•	•				•			
Airports	•		•	•	•			•		•	•			•			•			
Airlines	•				•		•			•	•									
Amusement Parks			•	•			•								•				•	
Army Posts	•		•	•	•	•		•		•	•				•		•		•	
Auditoriums							•					•			•			•	•	
Apartment Houses				•												•			•	•
Architects																				
Banks			•	•			•			•	•								•	
Breweries		•		•	•		•		•								•			
Boats						•	•	•						•					•	
Bridges				•				•											•	
Brokers							•			•					•		•			
Bus Terminals				•				•												
Camps	•			•			•			•					•		•			•
Canneries		•			•				•	•	•						•		•	
Carloading					•		•	•			•								•	
Cement Plants		•		•	•	•			•		•									
Centrifugal machinery		•			•	•			•	•										
Chemical plants		○		•	•	•			•	•	•		•						•	
Churches							•								•		•			
City governments			•	○				•		•	•			•			•			
Clinics	○						•				•			•	•					
Clubs														•	•					•
Chain stores	○		•	•			•				•	•	•							
Carnivals			○				•					•			•					
Circuses			•	○				•				•			•				•	
Colleges	○						•			•	•				•		•	•		•
Contractors																				
Consultants																				
Dairy Equipment Manufacturers		•		•	•				•											
Dance Studios	•											•						•		
Department Stores	•			•						•	•	•	•							
Die Makers	•	•					•		•											
Dental Schools	•														•		•			
Distilleries				•					•	•	•									
Docks								•											•	
Drug Manufacturers	•			•					•		•									
Dyers—Industrial							•		•	•										
Electrical Contractors																				
Electric Instrument Manufacturers		•			•	•			•											
Elevator Manufacturers		•			•		•													
Engineers																				
Express Companies			•	•	•			•		•	•								•	
Farm Equipment Manufacturers		•		•	•		•			•	•									
Fibre Products Manufacturers		•			•		•		•	•	•									
Food Processors	•				•				•		•									
Foundries		•			•	•	•		•	•										
Freight			•	•	•			•												
Funeral Directors															•					
Furnace Manufacturers		•				•	•		•											
Garages			•	•			•												•	
Gas Equipment		•		•		•			•		•									
Gas Plants				•		•	•			•	•									
Glass Plants		•		•	•	•			•											
Hardware Manufacturers		•			•		•		•	•										
Hospitals	•						•				•			•					•	
Homes																•				
Hotels											•			•	•	•				•
Hydroelectric Plants				•		•				•	•									

Figure 1. Closed-Circuit Television Applications -- Courtesy John F. Rider Publisher, Inc., New York (Continued)

APPLICATION	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Insurance Companies	●									●	●									
Ironworks		●			●	●			●											
Jewelry Manufacturers		●	●				●		●	●										
Jewelry Schools	●										●		●							
Jails			●				●													
Knitting Machine Manufacturers		●		●					●											
Laboratories	●					●			●	●	●									
Laundry Machine Manufacturers		●		●	●					●	●									
Leather Goods Manufacturers		●			●				●	●										
Libraries							●				●									
Lubricant Manufacturers				●	●	●			●											
Lumber Mills				●	●		●													
Machine Shops		●			●				●											
Machine Tool Manufacturers		●		●	●	●				●										
Mining				●	●	●	●													
Milling Operations	●	●				●	●													
Metal Fabricators		●			●	●														
Mortgage Companies	●										●									
Naval Installations	●		●	●		●	●				●			●	●					●
Night Clubs												●			●					
Needle Trades	●	●								●										
Nursing Homes			●																●	
Oilfield Equipment Manufacturers		●		●	●	●			●											
Optical Schools	●									●										
Packing				●	●				●											
Paint Manufacturers				●	●				●		●									
Paper Mills		●			●															
Pharmaceutical Manufacturers		●		●	●				●	●	●									
Photographers—Commercial	●											●						●		
Plastic Manufacturers		●		●		●			●											
Police Departments			●				●	●											●	
Prisons			●				●				●								●	
Power Plants				●		●	●				●									
Post Offices			●																	
Radio Stations	●											●						●		
Race Tracks															●					
Railroads							●	●						●					●	
Refineries		●		●		●			●		●								●	
Schools - General	●						●				●				●				●	
Shipyards					●		●	●											●	
Shoe Manufacturers		●			●				●											
Steel Mills		●		●	●	●		●	●		●								●	
Textile Manufacturers		●			●				●											
Tobacco Manufacturers					●		●		●											
Toll Bridges			●					●												
TV Stations																		●		
Universities	●									●	●							●		●
Warehouses				●				●			●								●	
Water Plants				●			●		●											
Wind Tunnels						●	●													
Woolen Mills		●		●	●				●	●										

APPLICATION CODE

A Training
B Production Control
C Surveillance
D Property Protection
E Material Handling
F Dangerous Viewing
G Remote Observation
H Traffic Control
I Process Control
J Work Coordination
K Centralized record viewing
L Merchandising
M Display
N Silent paging
O Accommodation of Overflow crowds
P Protection—Homes and Apartment Houses
Q Information
R TV and stage rehearsals
S General action monitoring
T Community Antenaplex

Figure 1. Closed-Circuit Television Applications -- Courtesy John F. Rider Publisher, Inc., New York (Concluded)

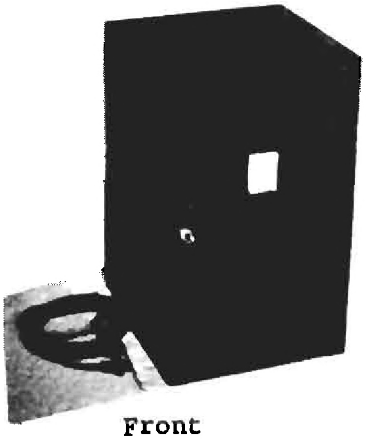
OPERATION SHEET

PART NUMBER	OPP	PROD	SPARES	EDITION	TYPE MFG	TOOLING	DCC	METHODS SERIAL	MODEL	DATE	PAGE
3C10047-119		X	X	502		M			C-141	03-21-63	1

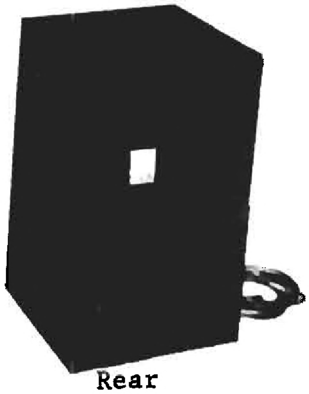
PART NAME	FILLER-PULLEY ASM	GROUP	10.02
PLANNER	CHAPMAN 4049	AUTHORITY	4CA265
MATERIAL	.250 BARE PLATE X 1.0 X 2.0 2024-T351 AL CLAD QQ-A-355	MATERIAL CODE	

B.C.	C.C.	L.C.	OPER	TOOL CODE	DESCRIPTION: TOOL IDENTIFICATION / DESCRIPTION	T.S. INIT.	STANDARD HOURS SETUP	STANDARD HOURS RUN/100	QUAN. INSP. REJ.	QUAN. INSP. ACPT.
54	54	622	010		LAYOUT .80 X 1.77	BR	20	00		
		394	020		SHEAR .80 X 1.77	BR	15	17		
		668	030		IDENTIFY R/S A PCT.	BR	10	03		
57			040		INSPECT					
					CC-	TOT	45	20		
18	42	104	050		(F) MPS 1204	BR	09	06		
		140	060		(1) (1)	BR	07	40		
		140	070		(29) COLOR NO. 20372	BR	11	20		
		668	080		IDENTIFY R/S	BR	10	13		
57			090		ROCKWELL INSPECT					
					CC-	TOT	37	79		
			100		STOCK					
			999		NOTE (2) RIVET HOLES DRILLED					

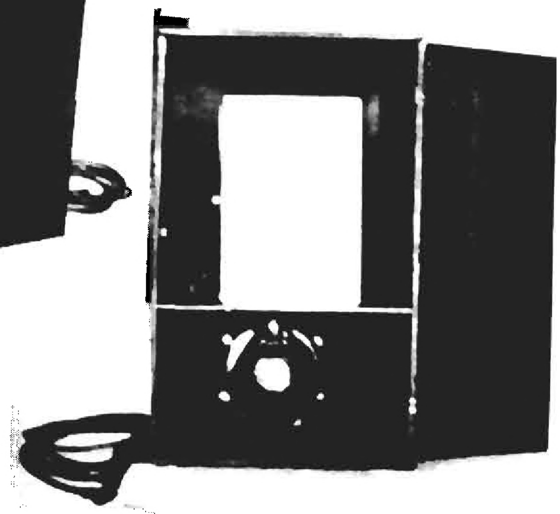
Figure 2. Lockheed Instruction Card



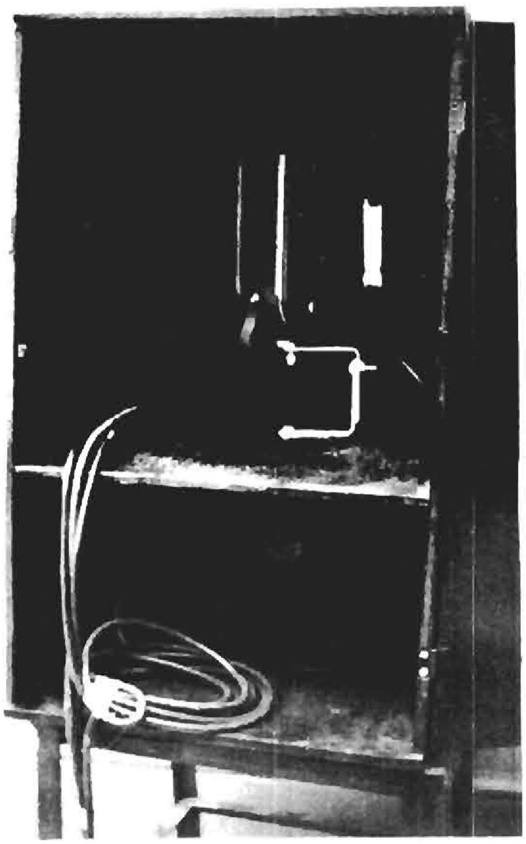
Front



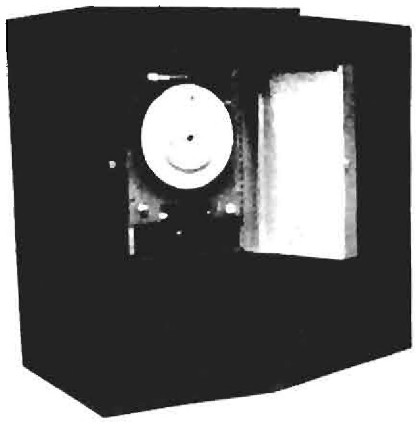
Rear



Timer (Top)
Vibration Meter (Bottom)

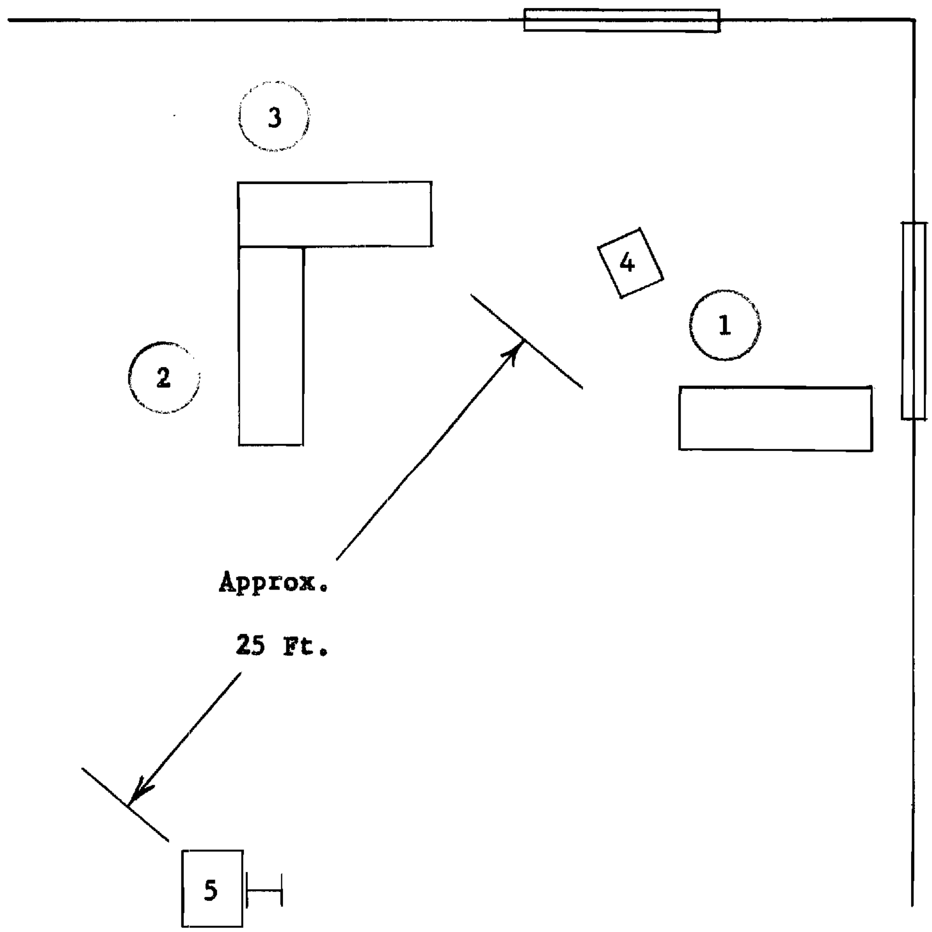


Camera In Place



Timer Open

Figure 3. Memomotion Camera Cabinet



1. EXPERIMENTAL
2. CONTROL
3. SECOND CONTROL
4. TV CAMERA
5. MM CAMERA

Figure 4. Experimental Installation -- Plan View

Left Hand			Right Hand
Pick up plastic block	0	0	Pick up steel clip
Position plastic block	0	0	Position steel clip
Wait		0	Pick up screw
Wait		0	Position screw

Repeat first four steps, four additional times

Wait		0	Reach and grasp screwdriver
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Push 5 assemblies into box	0	0	Return screwdriver

Figure 5. Operation Chart -- Experimental Operation.

Left Hand			Right Hand
Push base into jig	0	0	Pick up bus bar
Pick up 2 contacts	0	0	Position bus bar
Wait		0	Pick up screw shell
Position 2 contacts	0	0	Position screw shell
Pick up washer	0	0	Pick up washer
Drop washer in place	0	0	Drop washer in place
Pick up screw	0	0	Pick up screw
Drop screw in place	0	0	Drop screw in place
Wait		0	Reach and grasp screwdriver
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Wait		0	Return screwdriver
Wait		0	Place assembly in box

Figure 6. Operation Chart -- Control Operation

Left Hand			Right Hand
Pick up screw shell	0	0	Pick up bus bar
Position shell in jig	0	0	Position bus bar
Pick up plastic base	0	0	Pick up bus bar
Position plastic base	0	0	Position bus bar
Wait		0	Pick up screw
Hold	0	0	Position screw
Wait		0	Reach and grasp screwdriver
Hold	0	0	Position screwdriver
Hold	0	0	Tighten screw
Place sub-assembly in chute	0	0	Return screwdriver

Figure 7. Operation Chart -- Second Control Operation

Sex	Female
Age	47
Education	7th grade
Time with company	2½ years
Experience on job	10 months
Absentee record	Leave of absence-two mos. in '61
Marital status	Widowed
Children	2
Reason for working	To support children
Emotional stability	Good*
Anti-company	No*
Anti-union	No*
Efficiency rate	Average*

*Estimates of plant manager, general foreman, and floorlady.

Figure 8. Characteristics of Experimental Operator

Sex	Female
Age	35
Education	9^{th} grade
Time with company	2½ years
Experience on job	2 weeks
Absentee record	Leave of absence-one mo. in '61
Marital status	Married
Children	Unknown
Reason for working	"Need to work to pay bills"
Emotional stability	Good*
Anti-company	No*
Anti-union	No*
Efficiency rate	Average*

*Estimates of plant manager, general foreman, and floorlady.

Figure 9. Characteristics of Control Operator

Sex	Female	
Age	29	
Education	10^{th} grade	
Time with company	2½ years	
Experience on job	10 months	
Absentee record	Poor	
Marital status	Husband away in service	
Children	Small daughter	
Reason for working	Not given in personnel record	
Emotional stability	Good*	
Anti-company	No*	Relatives also
Anti-union	No*	work for company
Efficiency rate	Average*	

*Estimates of plant manager, general foreman, and floorlady.

Figure 10. Characteristics of Second Control Operator

Tape Footage	Speaker	Conversation
0-100		Shop noise
100	General Foreman	Hi
100	Worker	Hello
100	General Foreman	About that television -----.
100	Worker	Yea
101	General Foreman	Well, we've selected you to be the star of television out there. We've got this thing in here to try it and see how it's going to work out.
102	Worker	How it will work?
102	General Foreman	To test it. We're not going to put it on you, so you won't be nervous all the time. We're going to put it on your hands. On the job -- so we can count the work once in a while.
104	Worker	O.K.
104	General Foreman	The reason we've selected your job is because it is one that goes on all the time. It's something that we can get a little bit of evaluation. Just wanted to explain it to you so that you wouldn't wonder what in the world was going on here.
107	Worker	Well I take it that way, I mean I started with my ----. In fact I want to see what I have out there and set up for five pieces at a time and ----.
111	General Foreman	You do it just like you've been doing. Just exactly.
112	Worker	I mean ---------------.

Figure 11. Transcript of Conversation Before Television Installation -- Between General Foreman, Floorlady, and Experimental Worker. (Continued)

113	Floorlady	Right, the last batch wasn't too good.
114	Worker	If my screwdriver works all right and I've got things I can work with I can get along.
115	General Foreman	Right.
116	Worker	Sometimes ------------.
117	Worker	You know if you got stuff there to work with? Now ---------------.
117	General Foreman	That's right.
118	Worker	The set-up to work with -----------.
118	General Foreman	That's true of everybody out here. ------- to work with.
118	Worker	To work with. All I know -----. I can't work at all with that.
120	General Foreman	That's right. We're not taking you. Don't worry about it. We're just going to have it on your hands to see the work. We're just checking out the television and to see how it's going to work.
123	Worker	That's right.
123	General Foreman	We're checking production. We don't know -- we're just getting acquainted with it. I doubt if we'll buy it.
125	Worker	Well, --------- it's all right. Those stack ups ------- I don't have room to work ----------.
128-140		Too noisy to understand.
141	General Foreman	I'm going to set it up. Once I get it set up, I'd appreciate it if you'd kinda leave it alone.

Figure 11. Transcript of Conversation Before Television Installation -- Between General Foreman, Floorlady, and Experimental Worker. (Continued)

142 End of conversation

Note: The tape recorder was in a company packing box, under a table which was adjacent to the general foreman's desk. The microphone was outside, but concealed.

Figure 11. Transcript of Conversation Before Television Installation -- Between General Foreman, Floorlady, and Experimental Worker. (Concluded)

Tape Footage	Speaker	Conversation
0-528	Explanations to the experimental worker (Figure 11), miscellaneous office conversation, and shop noise. (The recorder was not turned off between discussions that were reported herein.)	
528	Plant Manager	Did you come in here to watch television?
529	Union Stewardess	That's what I guess you called me in here for wasn't it?
530	Plant Manager	We've heard a whole lot of rumors of complaints and yet no complaints have come up through the normal channels. Since our----we'll get one through the normal channels, and then we'll feed one back through the normal channels. What is the problem?
532	Union Stewardess	Well, it looks like you're treating them like they were communists. They say this is watching them like the communist people do. Watching every move you make and seeing - what it is all about.
535	Plant Manager	I don't have a camera on an operator. I've never put a camera on an operator. I wouldn't want a camera on myself. If I want to sit here and scratch my face, I'll scratch my face.
537	Union Stewardess	That's what they say too. Might be something that they'll want to do that they won't want you to see.
538	Plant Manager	We don't have the camera on the girl. Have we got the camera on the girl?
539	General Foreman	You can see what we have. Actually, I'm going to move that camera. Her arm is in the way. I don't care

Figure 12. Transcript of Conversations Between Plant Manager, General Foreman, Floorlady, Personnel Manager, and Union Stewardess. (Continued)

		about her, just the operation. The screwdriver and the little piece of plastic that she is putting together.
542	Plant Manager	We might be able to sit back here and by the use of these things --- we might see things that are not running right. This gives us an opportunity to expand our eyes foreward. ------- We want to see what we will see.
545	Personnel Manager	Did the girl herself complain about ------ talked to.
546	Plant Manager	------ has talked to the girl.
547	Union Stewardess	--------------
547	Plant Manager	She has complained?
548	Union Stewardess	No, she has been talked to.
548	Plant Manager	Yea,---------. Because we didn't want any misunderstanding with her. We didn't realize there would be a league of sympathetic followers.
548	General Foreman	The girl, the operator herself, hasn't said anything to you has she?
549	Union Stewardess	No she hasn't. The only thing she said was -------. She just thought that if you wanted something you could watch it out there, but you couldn't tell if you sat in here and watched it.
554	Plant Manager	It's not a case of watching. We're just seeing----. We're just playing with it right now, just trying it out to see how it works. We don't know whether it will be worth it or not.
555	Personnel Manager	Well, does the operator know that the camera is on her?

Figure 12. Transcript of Conversations Between Plant Manager, General Foreman, Floorlady, Personnel Manager, and Union Stewardess. (Continued)

556	Personnel Manager	--------
558	General Foreman	Well, actually, this is all we are going to do with it, right here, that's all. It will be on that one job that goes on all the time. It wouldn't do us any good to go out and get excited about it and get everybody all upset.
560	Union Stewardess	Well---------------.
561	General Foreman	---------- fiddled with it.
561	Union Stewardess	It followed --- everywhere she went this morning.
562	General Foreman	Somebody must have been out there---.
563	Union Stewardess	I don't know who it was but you could see everywhere ---- went this morning. It was right on her.
564	General Foreman	Well you can tell everybody.
564	Union Stewardess	Before the ----------.
565	General Foreman	They were playing with it, but that's where it's going to be until it's taken out.
566	Personnel Manager	Are you going to have a secret microphone?
567	General Foreman	No, we're not having anybody sneaking around corners trying to catch people doing things. It's going to be right there, and the only person concerned is going to be ------.
569	Plant Manager	We think with the television camera we can spot things going wrong------. So that the individual, or the tool, or whether it's the fact that they have no work or -------.

Figure 12. Transcript of Conversations Between Plant Manager, General Foreman, Floorlady, Personnel Manager, and Union Stewardess. (Continued)

571	Floorlady	Would I not --- if I had the right--.
572	Plant Manager	----- to get the job done. How are we going to find out?
573	General Foreman	She's said, if I have the right screwdriver bits and have parts all the time there's no problem. If we're sitting here and she stops, well it's not her fault. In 99 times out of 100 it's no reflection on the operator, I'll say that for sure. In 90 percent of the cases------.
580	Union Stewardess	Well, this morning it didn't sound logical to me ----------.
581	Plant Manager	We didn't explain it to everybody because we ----. The guy came and called on ------. Well, it's a small deal and we thought, "let's give it a whirl". And gee, all of sudden ----.
582	Union Stewardess	It really did --------.
583	Plant Manager	Now that everybody's got the word --.
584	Union Stewardess	I don't know --- I can't speak for everybody. They were upset about it this morning. Well, when they understand that you understand, are they going to be upset?
586	Union Stewardess	Well, I don't know ------. I can't speak for everybody.
588	General Foreman	Well, it's up to ---, I'd say, we ought to check with her first.
590	Plant Manager	She's not concerned. Talk to the girls will you ----?
592	Union Stewardess	You know they're -----------.
593	Plant Manager	I know and that's why I say ------- come through the normal channels----.

Figure 12. Transcript of Conversations Between Plant Manager, General Foreman, Floorlady, Personnel Manager, and Union Stewardess. (Continued)

595	Union Stewardess	-------no mistake -------- about ---. Just watching them, you know -------.
597	Plant Manager	No, I'm not watching them.
597-604		Too noisy to understand.
604	General Foreman	As far as I know, they set it out on the job Saturday and somebody moved it and played with it. I guess that was bound to be this morning.
605	Union Stewardess	Yes bound to ---------.
605	Plant Manager	When we came in that thing was focused over on you. We took it off.
607	General Foreman	It was intended to be on that job and it will be on that job. If there are any changes, whatever job it's put on, they will be notified -----. We will not be sneaky about it.
609	Union Stewardess	-------- a thing like that might be sneaky.
610	General Foreman	Well, we can be sneaky in other ways--.
610-621		Too noisy to understand.
621	Plant Manager	Would you get the word out?
621	Union Stewardess	I'll talk to them.
622	General Foreman	We know how ------ is doing ------.
622-630		Too noisy to understand.
630	Union Stewardess	I'll talk to them
		End of conversation

Figure 12. Transcript of Conversations Between Plant Manager, General Foreman, Floorlady, Personnel Manager, and Union Stewardess. (Concluded)

Period 1 Before Television Installation				No Observations Seven Weeks	2 TV Obs	Period 3 First and Second Weeks Following TV Removal		Period 4 Third and Fourth Weeks Following TV Removal	
M T W	M T W	M T W	T W T		M	T W	M T W	T W	M T W
8-13	8-20	8-27	9-4 9-6		10-29		11-5	11-13	11-19

Figure 13. Experimental Operation -- Time Breakdown

Period 1					No Observations Seven Weeks	2	3	No Work One Week	4	
M T W	M T W	M T W	T W	T		M	T W		T W	M
8-13	8-20	8-27	9-4	9-6		10-29			11-13	11-19

Figure 14. Control Operation -- Time Breakdown

Period 1			Operator Absent	No Observations Seven Weeks	2	3	No Work One Week	4	
M T W	M T W	M T W	T W T		M	T W		T W	M T W
8-13	8-20	8-27	9-4 9-6		10-29			11-13	11-19

Figure 15. Second Control Operator -- Time Breakdown

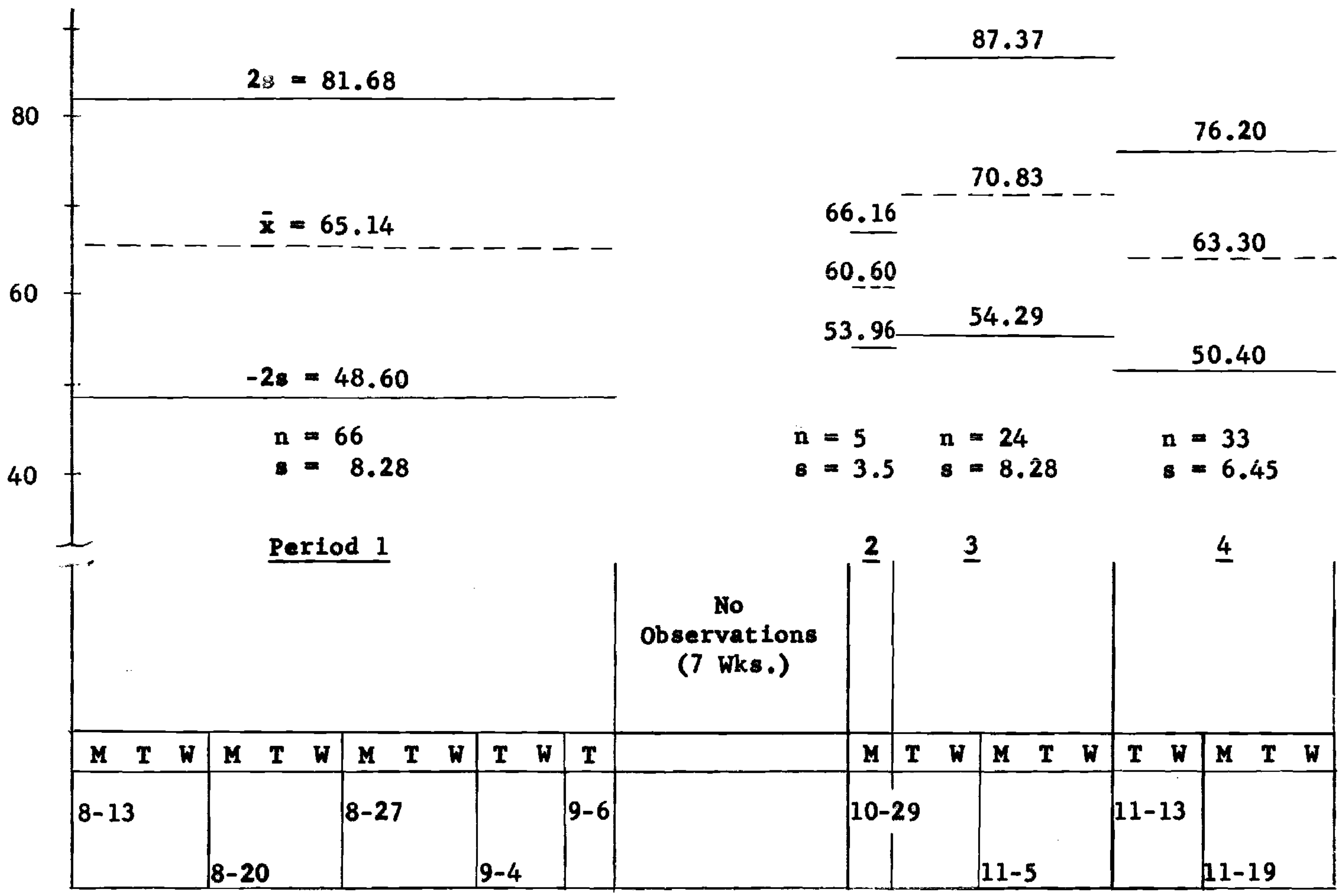


Figure 16. Experimental Operation -- Basic Data Summary

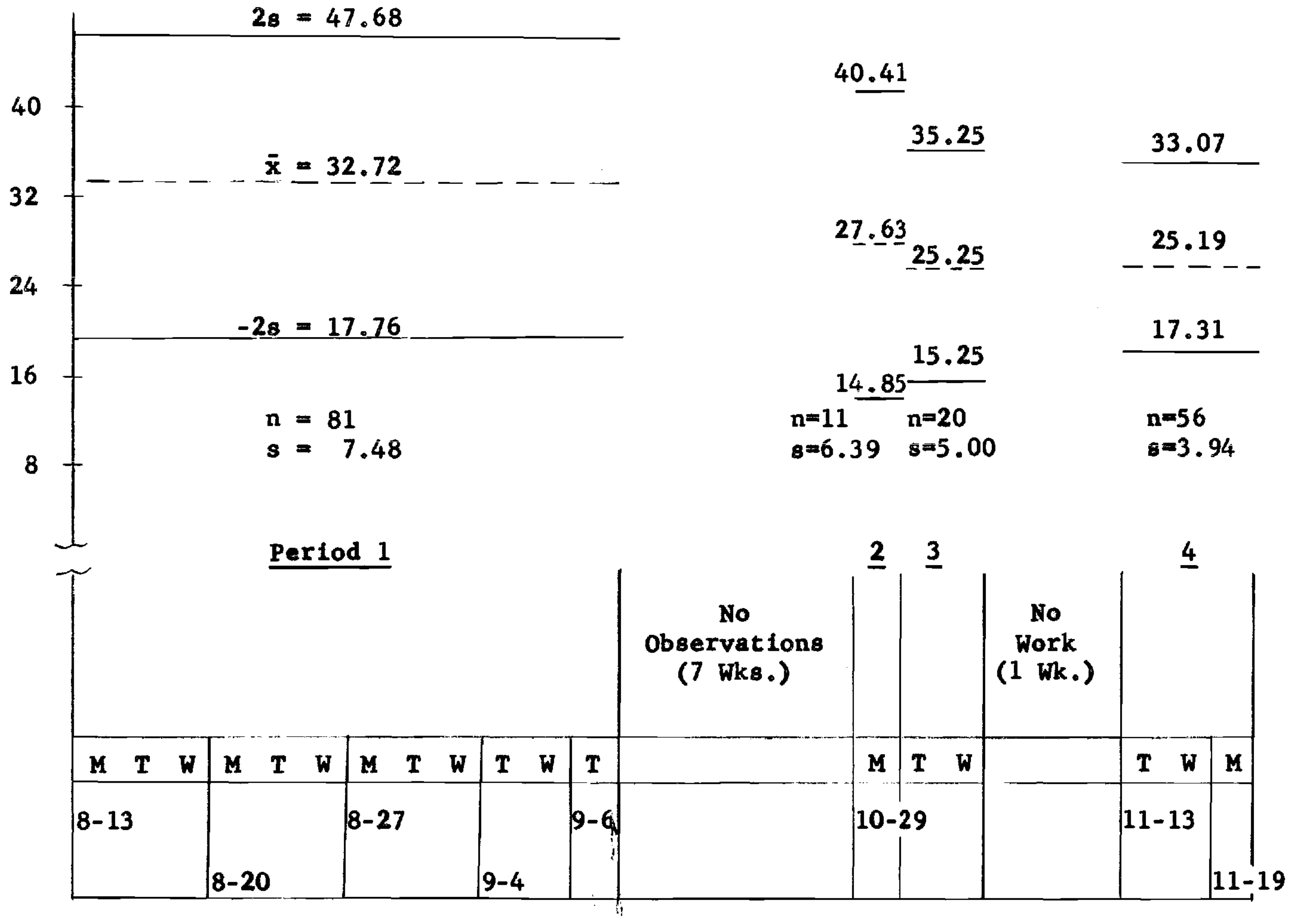


Figure 17. Control Operation -- Basic Data Summary

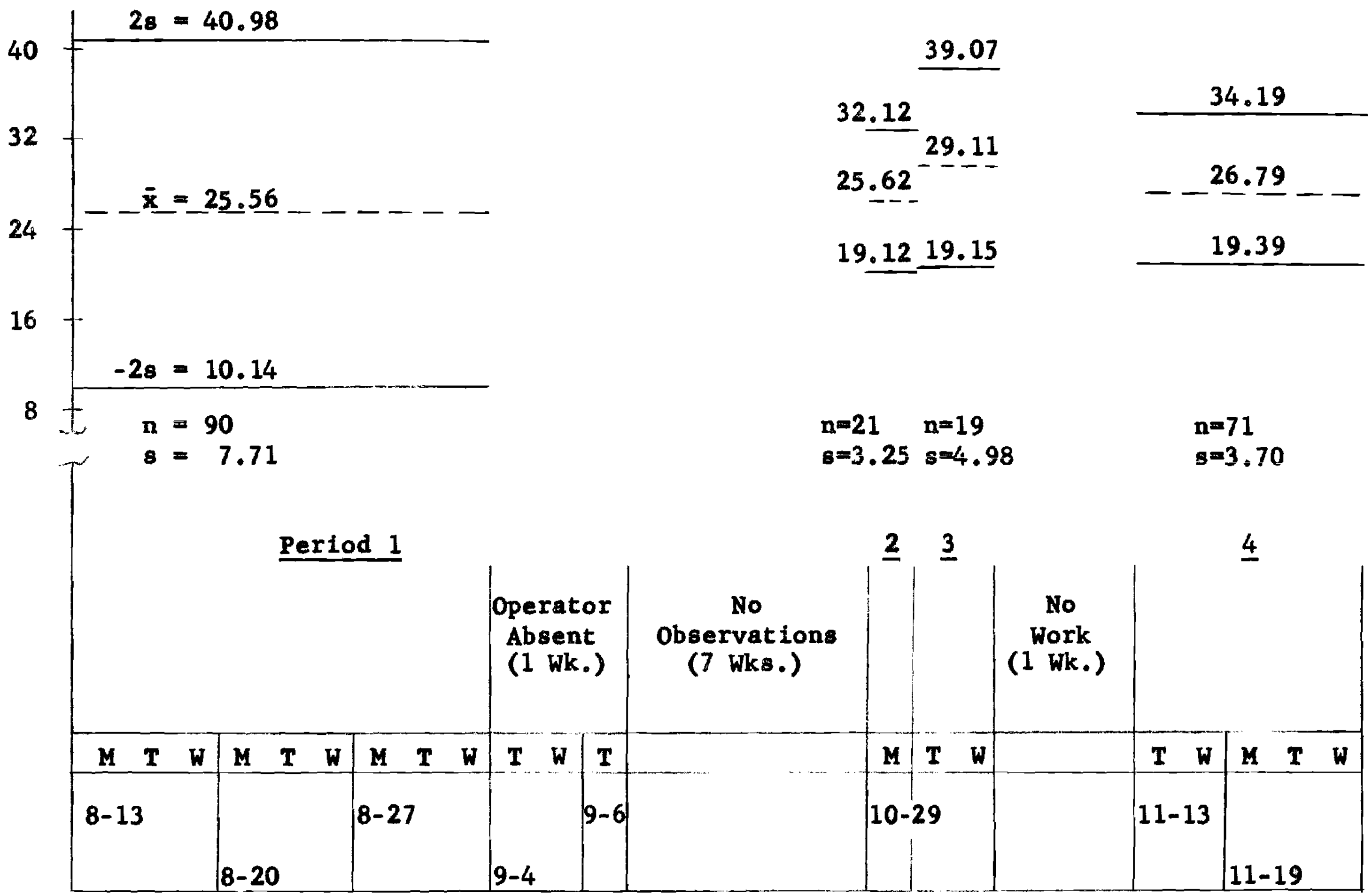


Figure 18. Second Control Operation -- Basic Data Summary

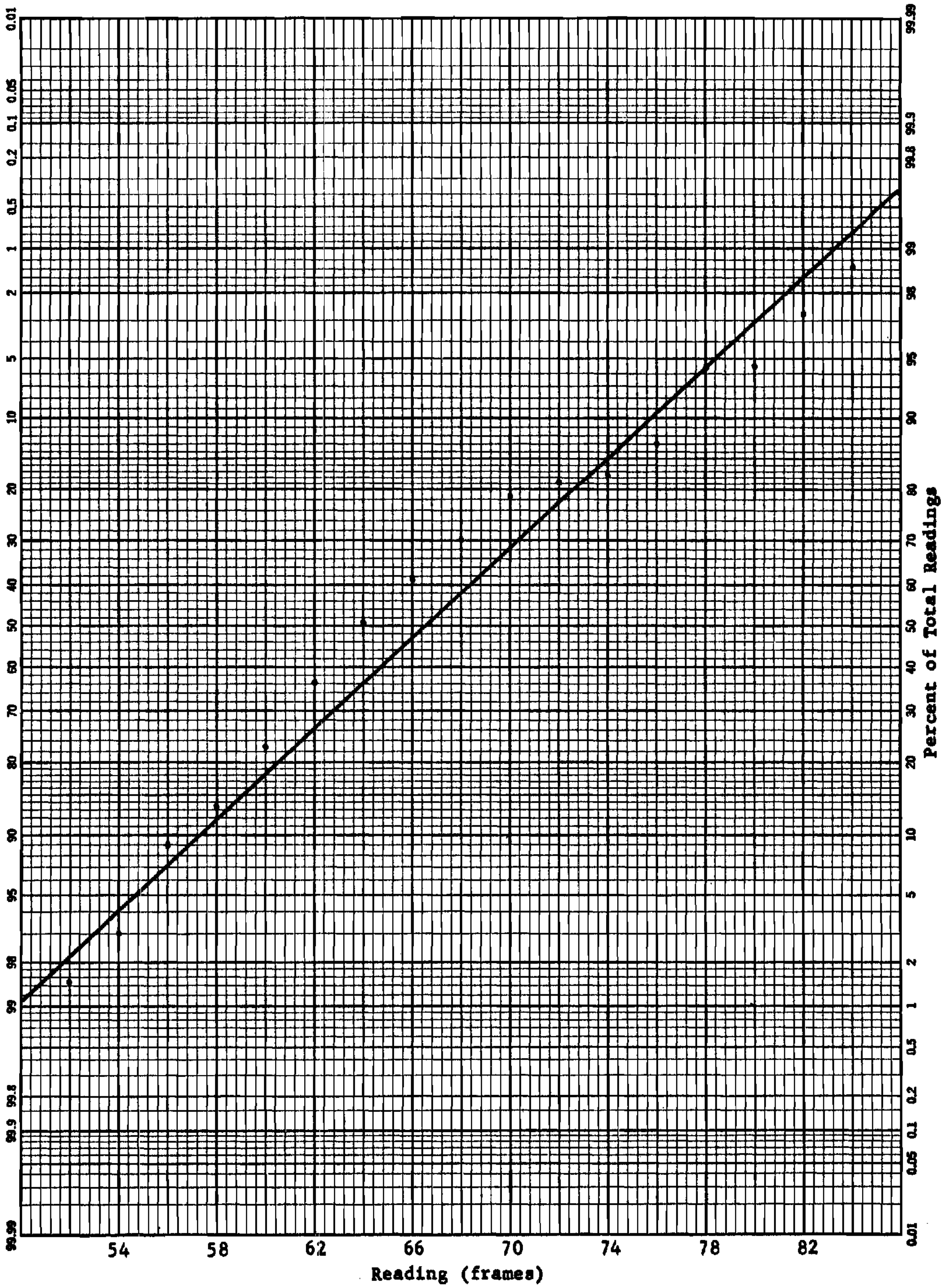


Figure 19. Graphical Test for Normality -- Experimental Before Television Installation

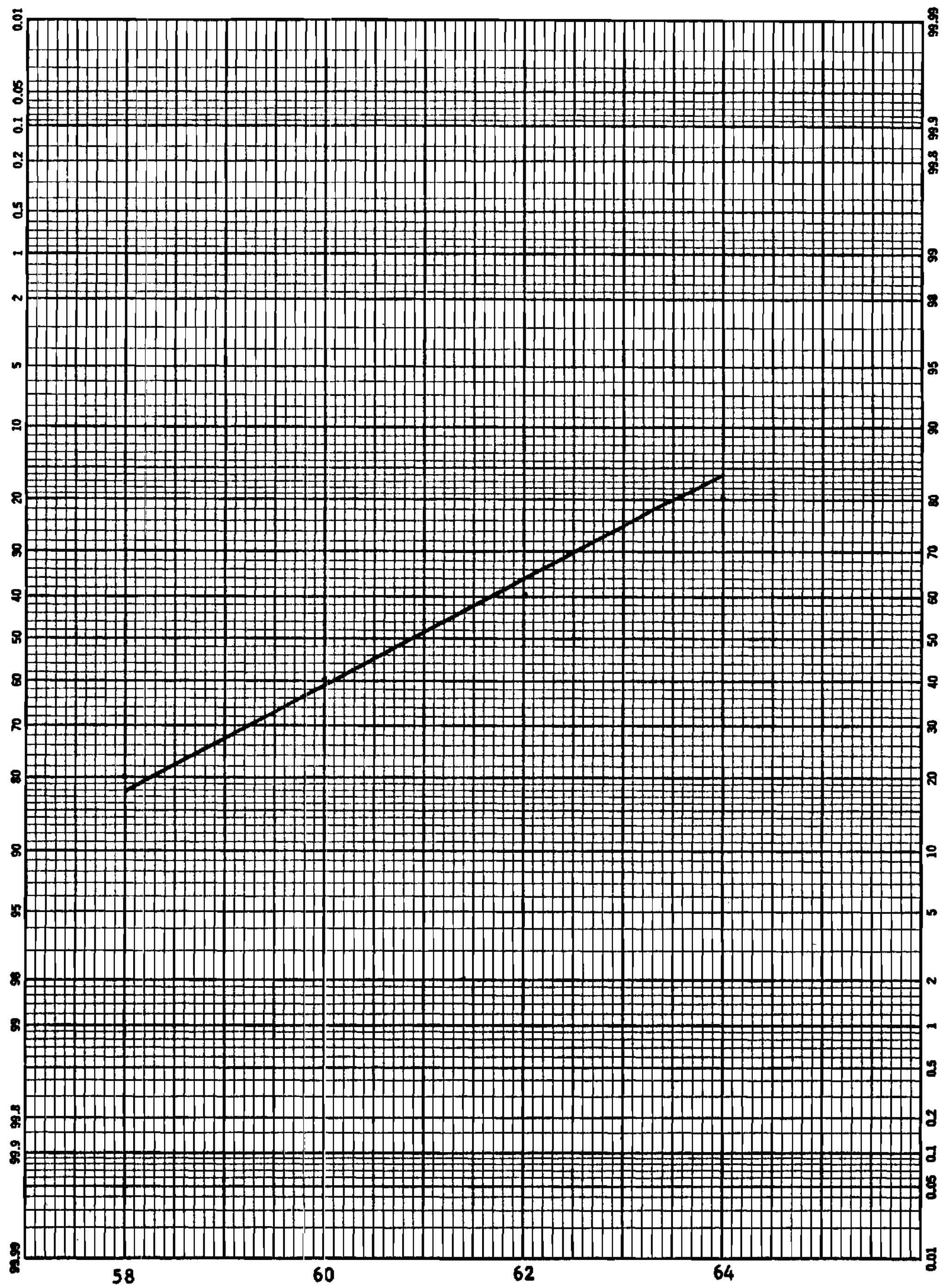


Figure 20. Experimental, During Television Functioning

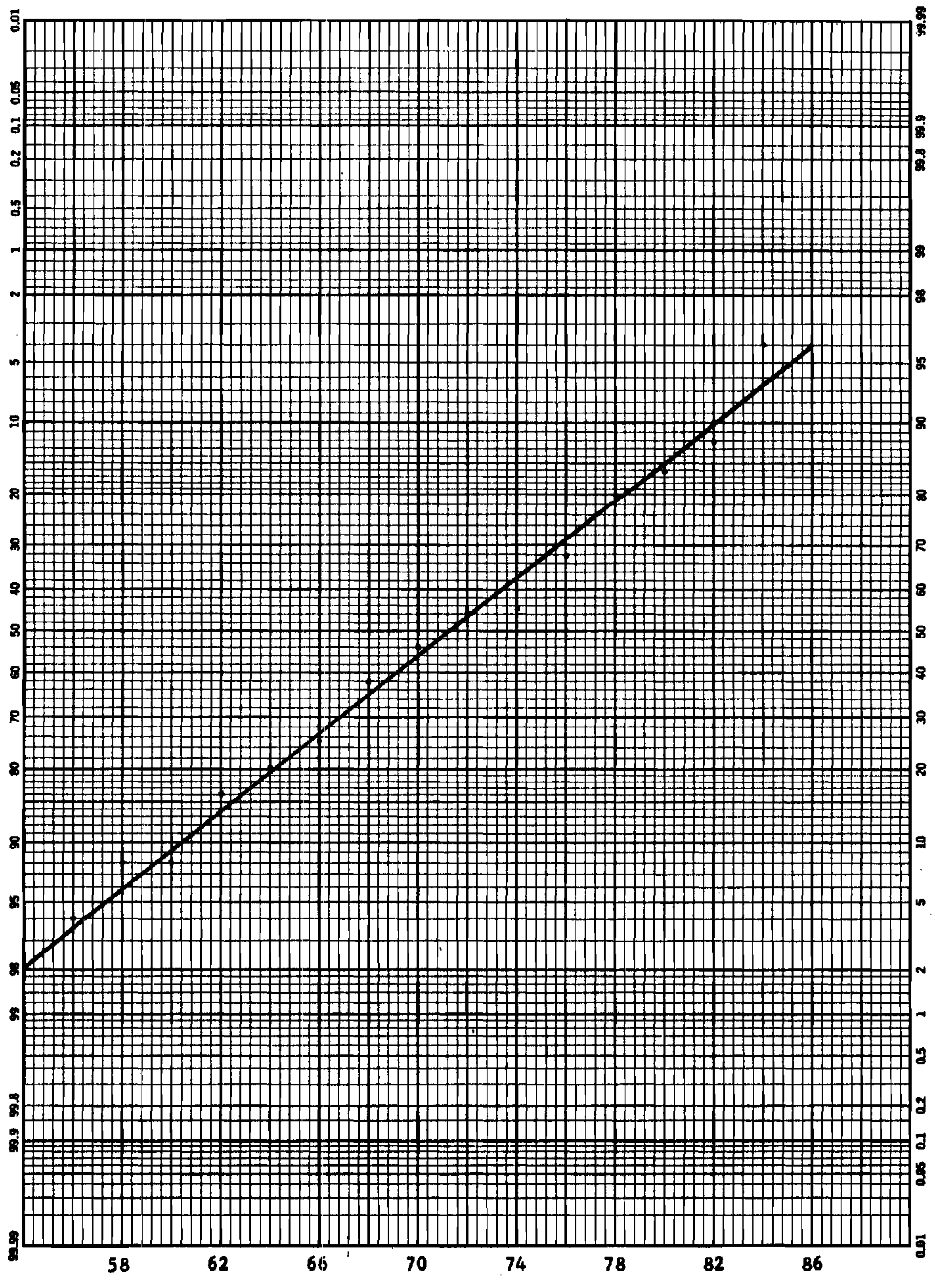


Figure 21. Experimental, During First and Second Weeks Following Television Removal

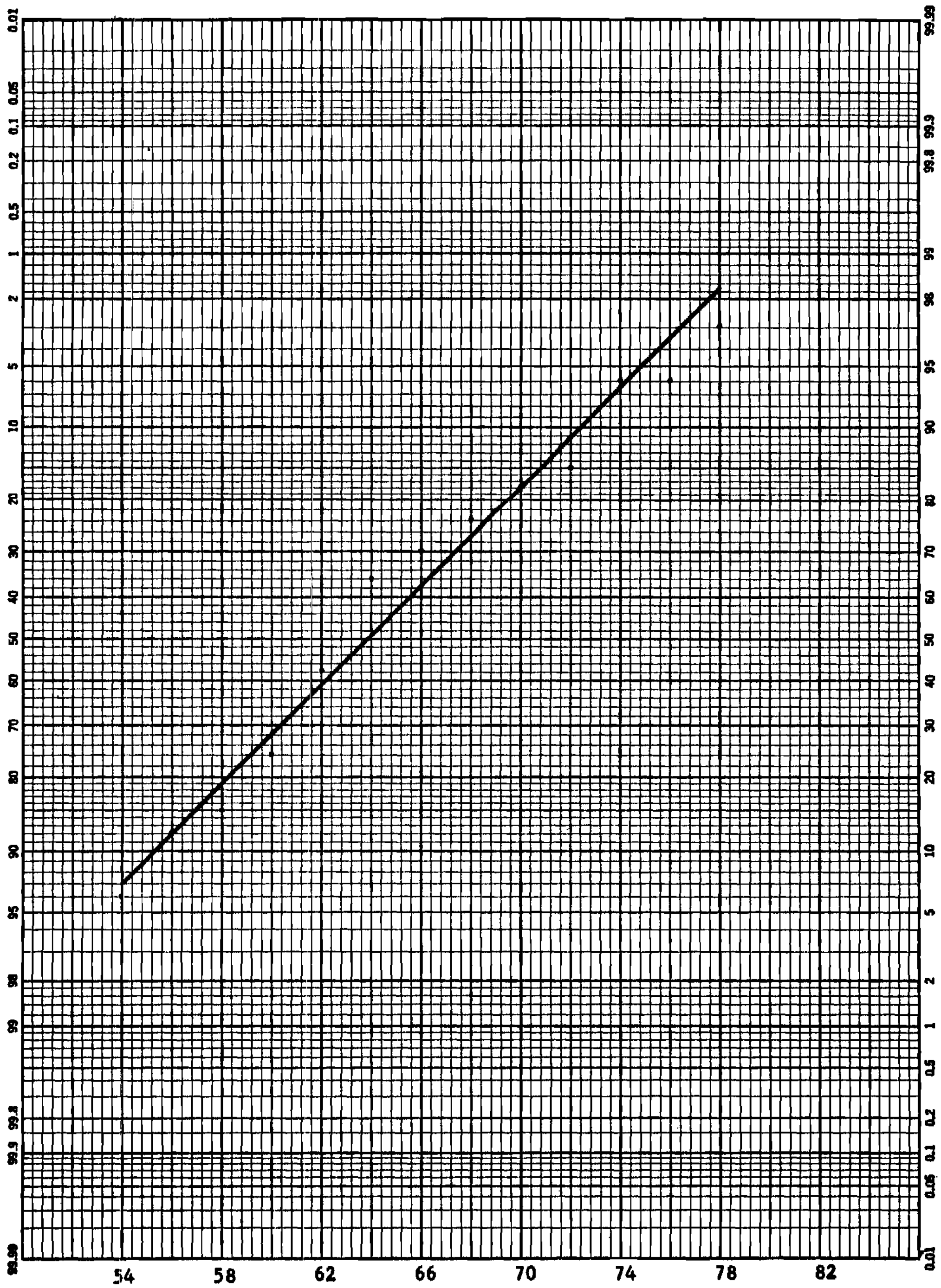


Figure 22. Experimental, During Third and Fourth Weeks Following Television Removal

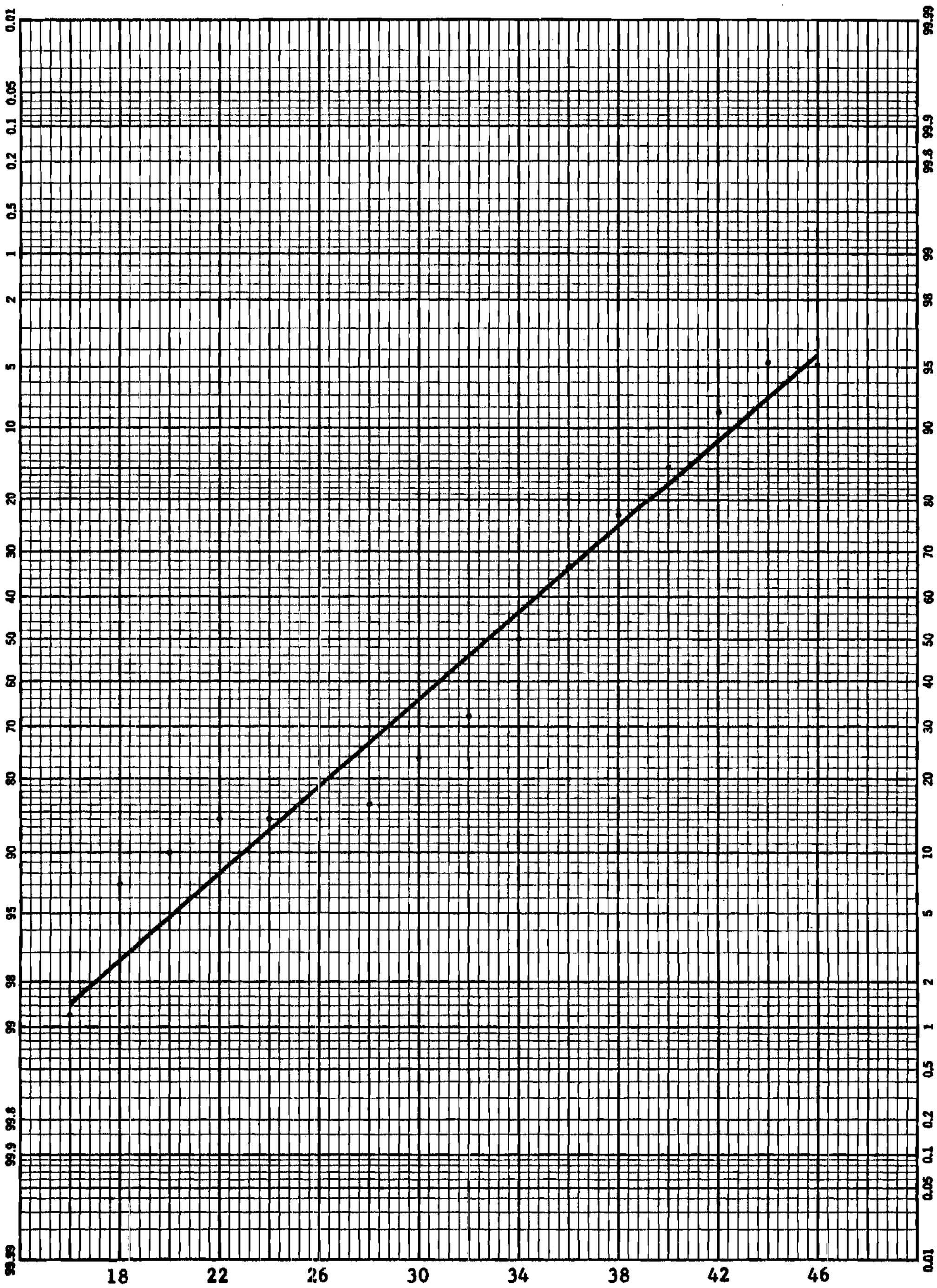


Figure 23. Control, Before Television Installation

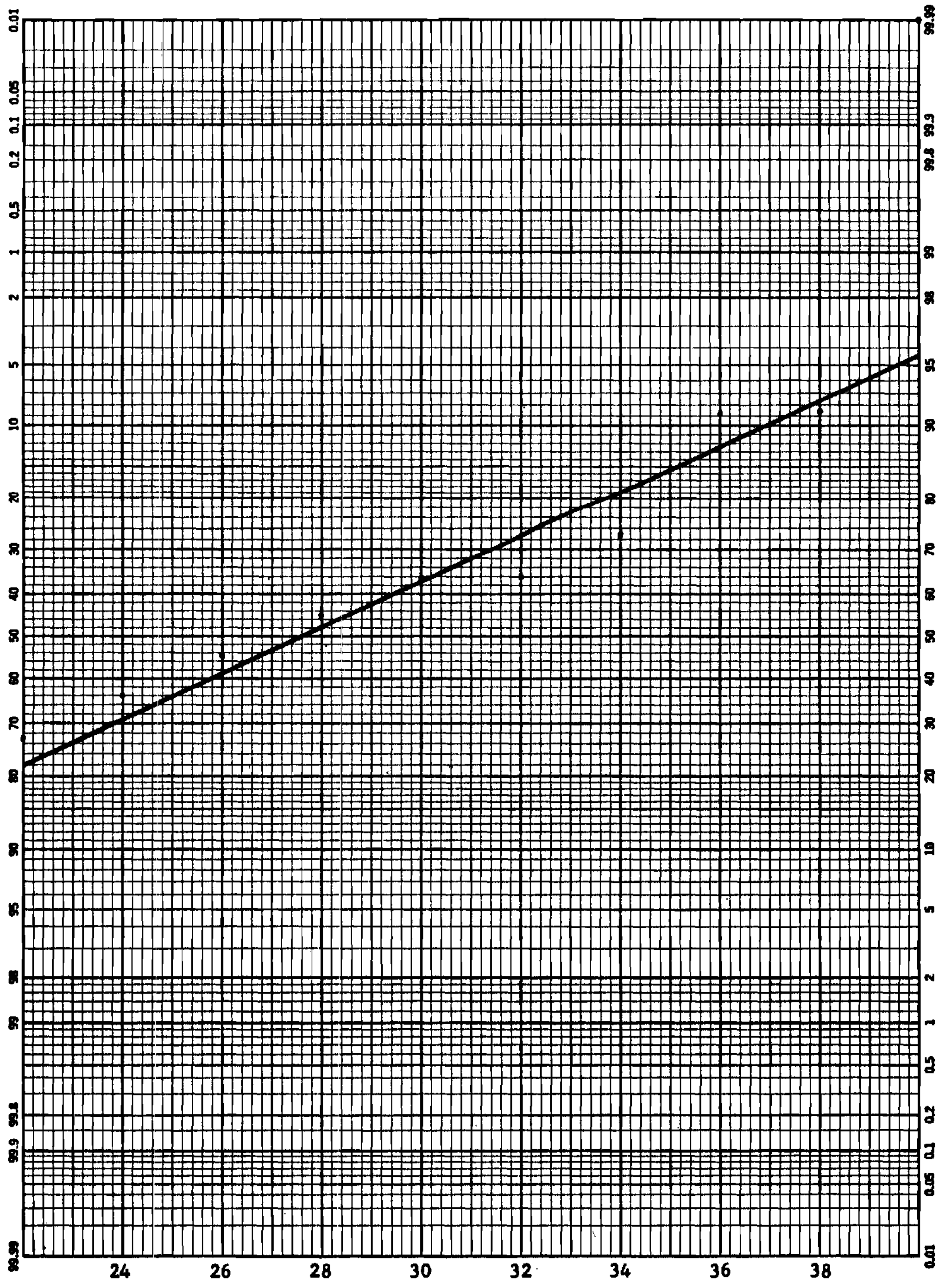


Figure 24. Control, During Television Functioning

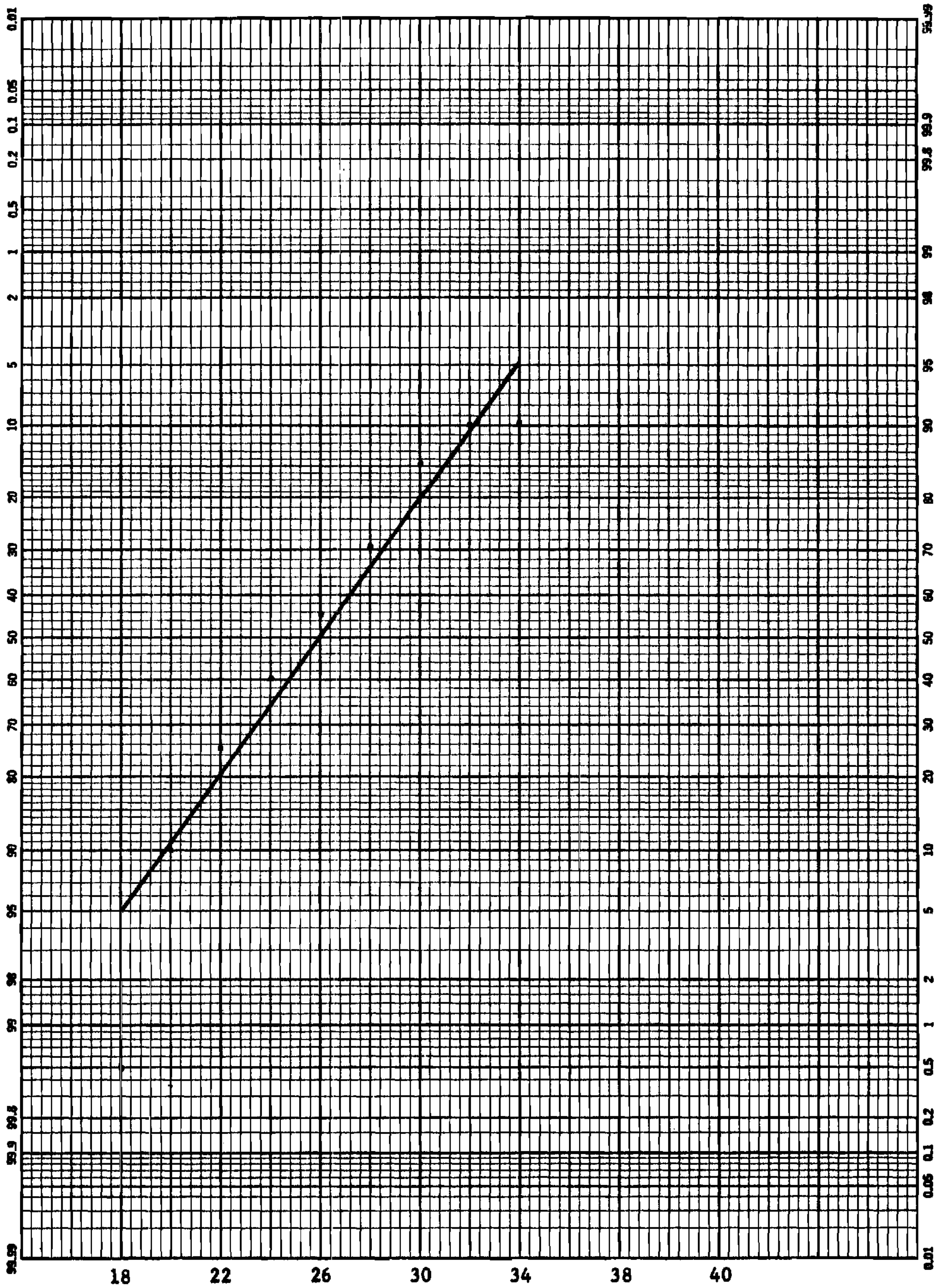


Figure 25. Control, During First Week
Following Television Removal

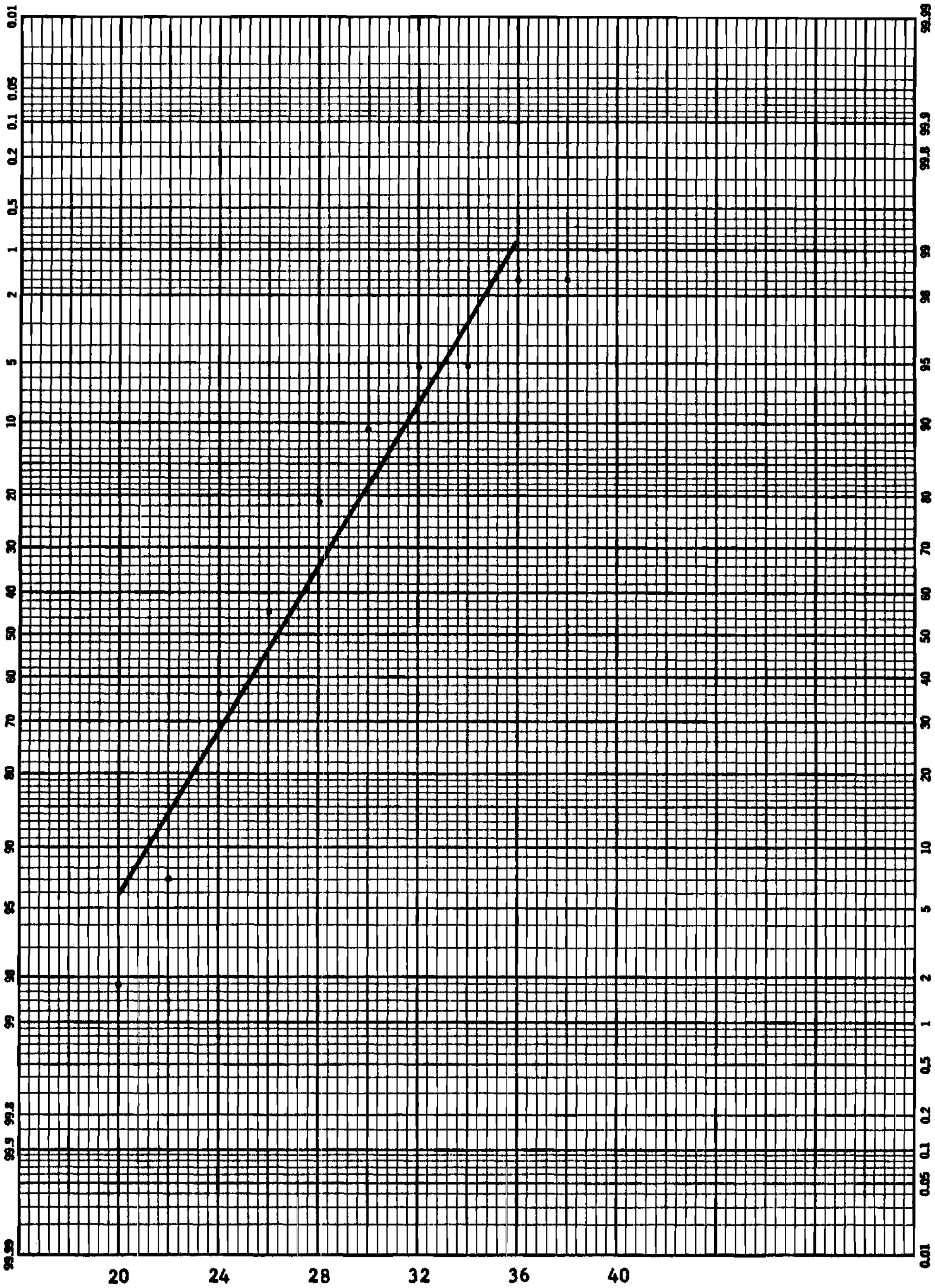


Figure 26. Control, During Third and Fourth Weeks Following Television Removal

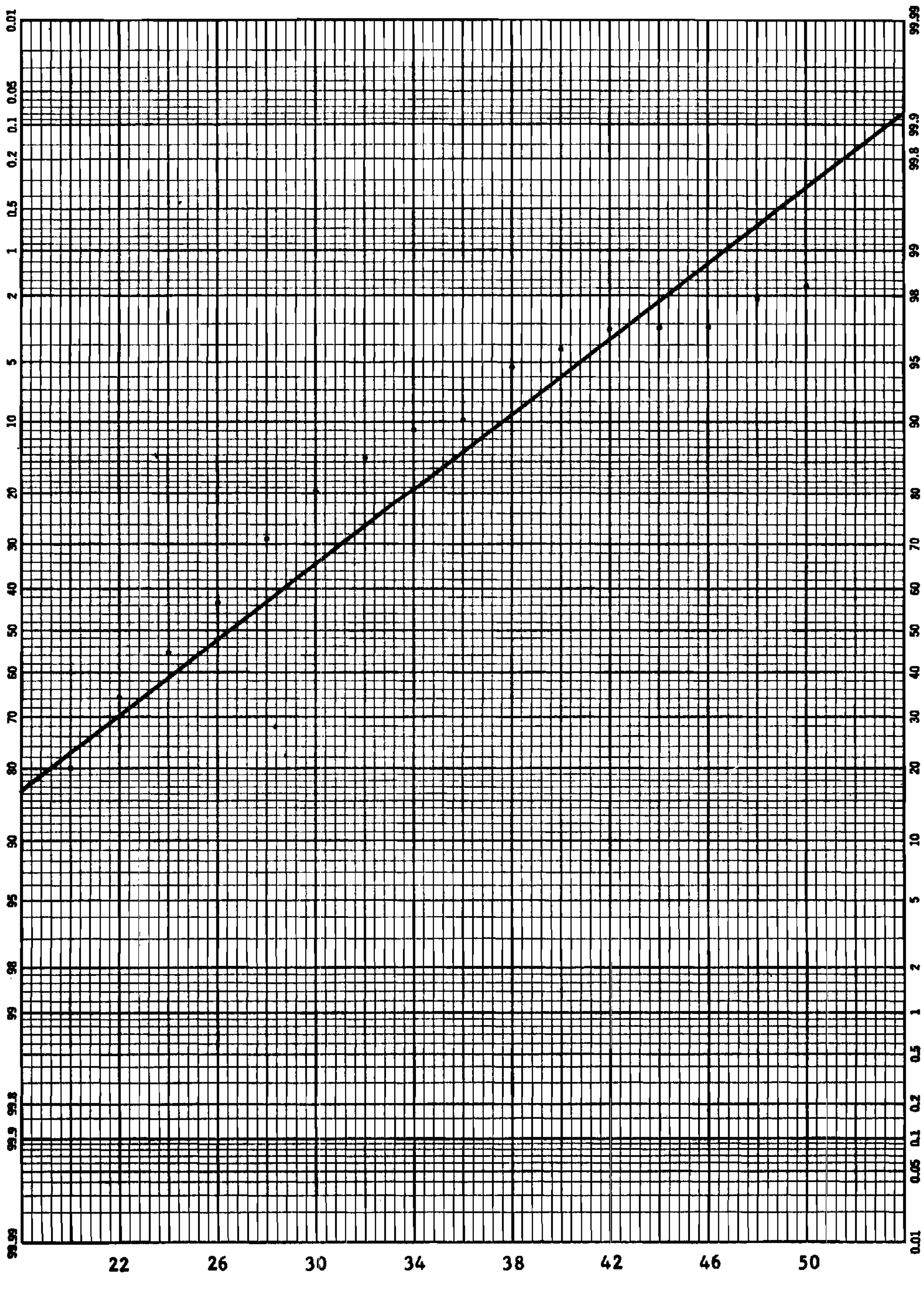


Figure 27. Second Control, Before Television Installation

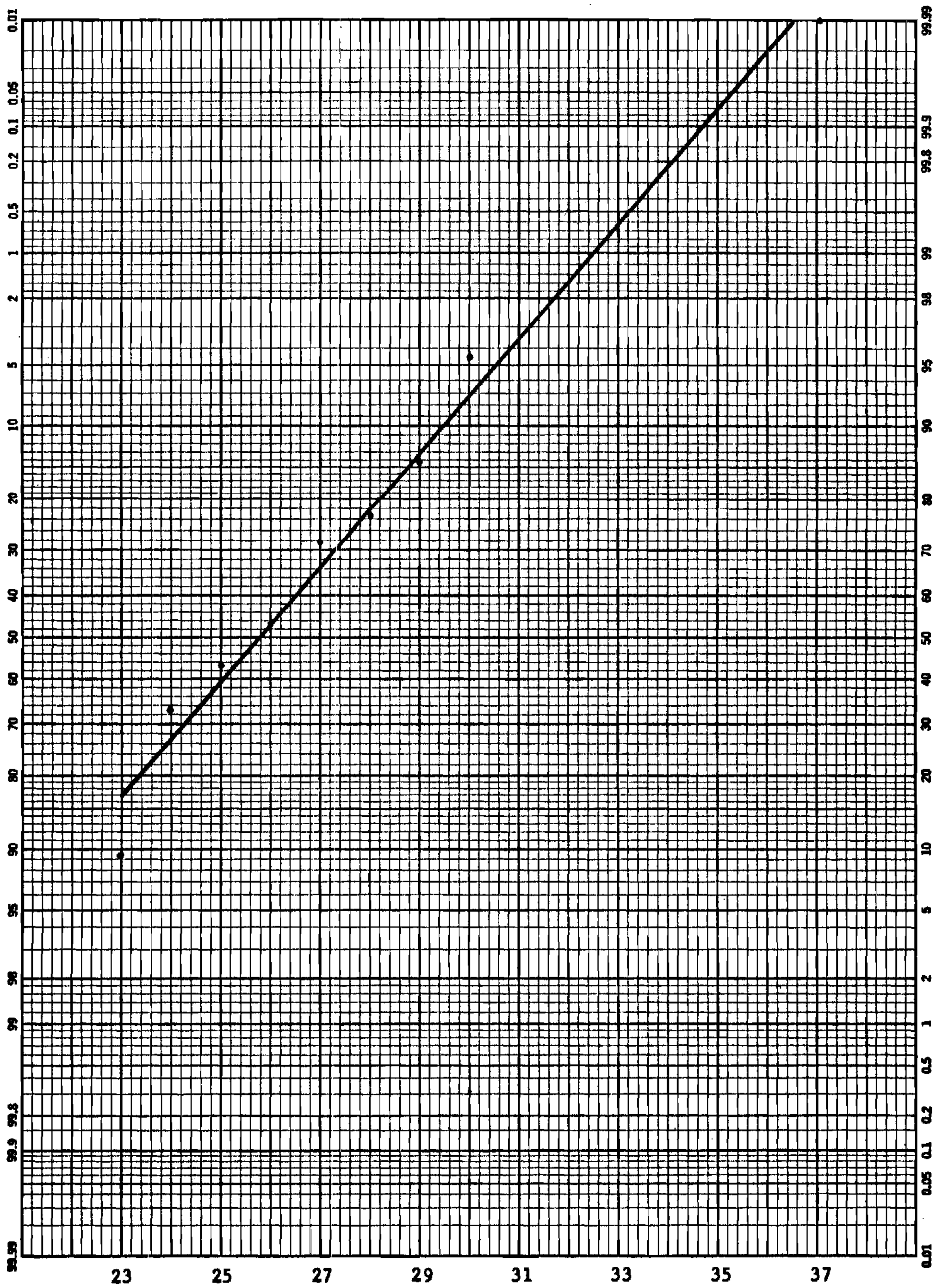


Figure 28. Second Control, During Television Functioning

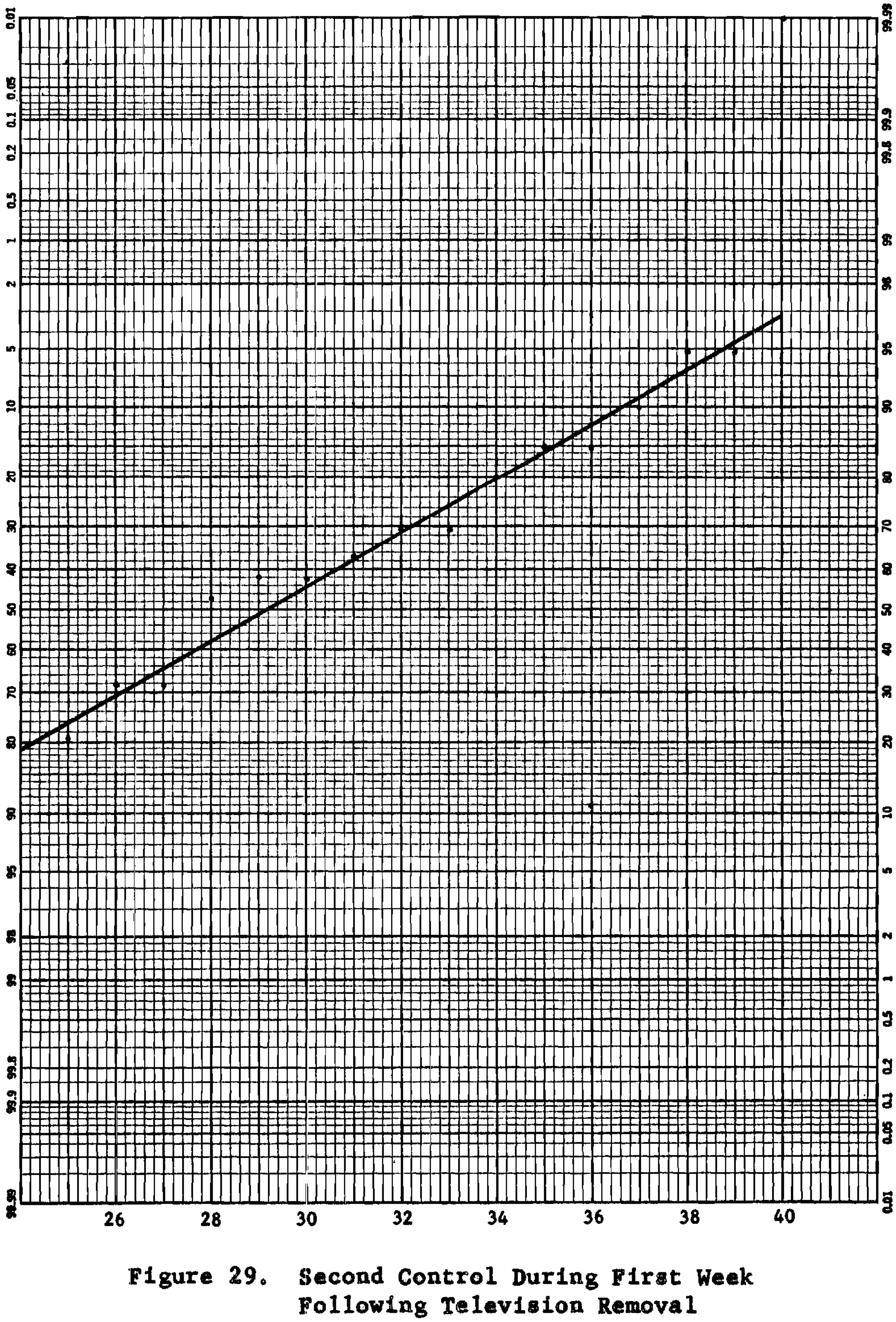


Figure 29. Second Control During First Week
Following Television Removal

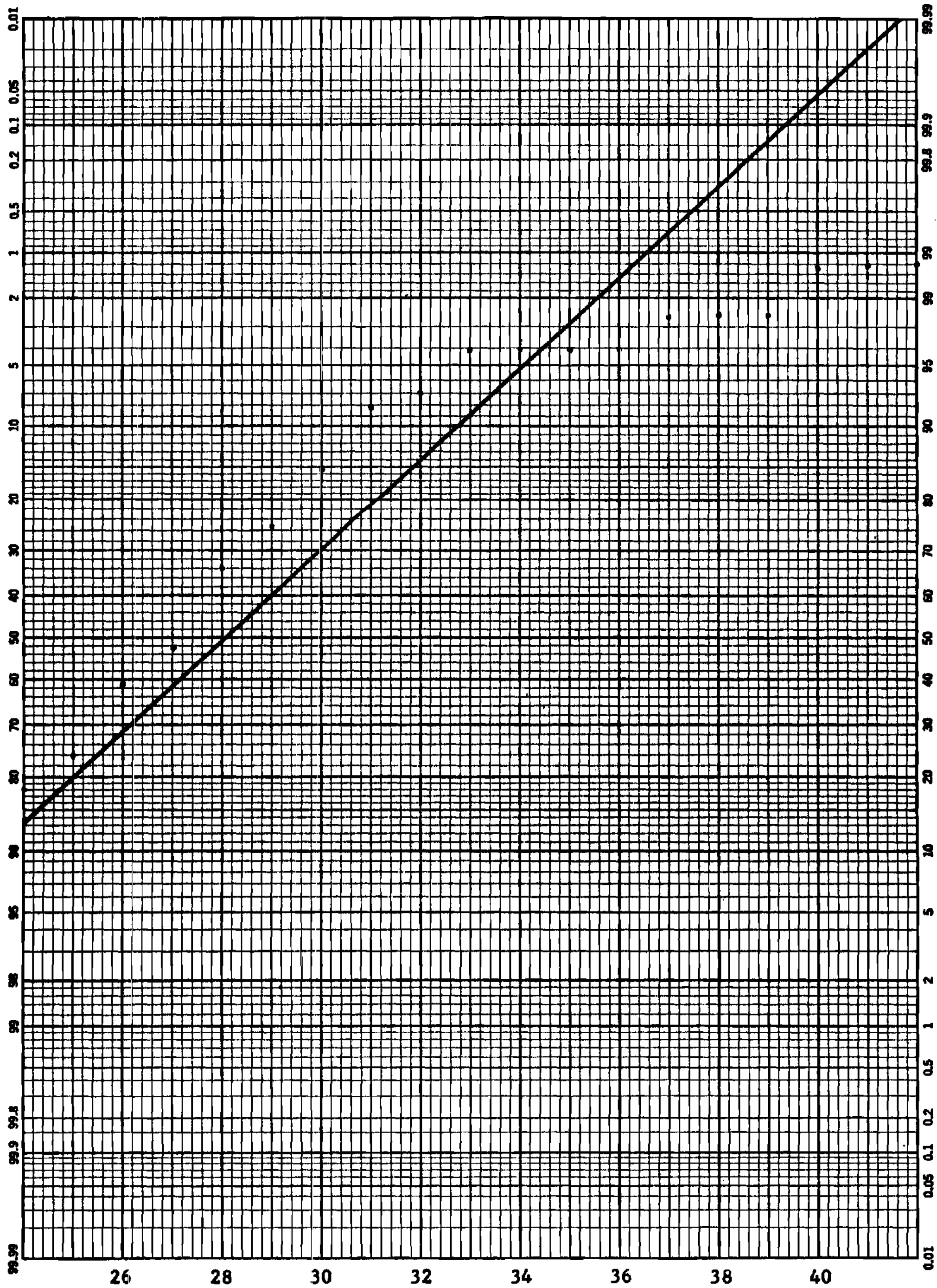


Figure 30. Second Control, During Third and Fourth Weeks Following Television Removal

$n = 66 \qquad \bar{x} = 65.14 \qquad s = 8.28$

Class Interval (Frames)	Act. F	Limits In Std. Units	Area Under Normal Curve	Theoretical f	F-f	$(F-f)^2/f$
78-98	4	1.55	.0606	4.00	.00	.000
72-78	9	.84	.1399	9.23	-.23	.006
66-72	13	.10	.2597	17.11	-4.11	.987
60-66	25	-.62	.2689	17.70	7.30	3.010
54-60	13	-1.35	.1824	12.04	.96	.077
48-54	2	-2.07	.0693	4.58	-2.58	1.452

$$\sum (F-f)^2/f = 5.532$$

Three degrees of freedom are lost because of the method of fitting. Theoretical number of cases, means, and variances are taken as actual. This leaves 3 degrees of freedom, since there are 3 class intervals.

From Table 2 of Bowker and Lieberman (66), at 3 degrees of freedom and .05 significance level, the percentage point of the chi square distribution = 7.815. Since the computed value = 5.532, we may assume normality.

Figure 31. Chi Square Test For Normality -- Experimental, Before Television Installation

$n = 24$ $\bar{x} = 70.83$ $s = 8.28$

Class Interval	Act. F	Limits In Std. Units	Area Under Normal Curve	Theoretical f	F-f	$(F-f)^2/f$
78-90	5	.90	.1841	4.42	.58	.076
72-78	6	.14	.2603	6.32	.32	.016
66-72	7	-.60	.2814	6.75	.25	.009
54-66	6	-2.04	.2536	6.09	-.09	.001

$$\sum (F-f)^2/f = .102$$

Chi square percentage point at 1 degree of freedom and .05 significance level = 3.841

Therefore: Assume normality.

Figure 32. Chi Square Test For Normality -- Experimental, During First and Second Weeks Following Television Removal

$n = 33$ $\bar{x} = 63.30$ $s = 6.45$

Class Interval	Act. F	Limits In Std. Units	Area Under Normal Curve	Theoretical f	F-f	$(F-f)^2/f$
70-80	5	1.04	.1492	4.92	.08	.001
65-70	5	.26	.2482	8.20	-3.20	1.250
60-65	13	-.51	.2976	9.89	3.11	.967
55-60	6	-1.29	.2065	6.81	-.81	.096
50-55	4	-2.06	.0788	2.61	1.39	.740

$\sum (F-f)^2/f = 3.054$

Chi square percentage point at 2 degrees of freedom and .05 significance level = 5.991

Therefore: Assume normality.

Figure 33. Chi Square Test For Normality -- Experimental, During Third and Fourth Weeks Following Television Removal

$n = 81$ $\bar{x} = 32.72$ $s = 7.48$

Class Interval	Act. F	Limits In Std. Units	Area Under Normal Curve	Theoretical f	F-f	$(F-f)^2/f$
45-50	4	1.67	.0475	3.85	.15	.005
40-45	8	.97	.1185	9.61	-1.61	.270
35-40	19	.31	.2161	17.58	1.42	.114
30-35	31	-.36	.2585	20.95	10.05	4.820
25-30	8	-1.03	.2079	16.82	-8.82	4.630
20-25	3	-1.70	.1069	8.66	-5.66	3.699
15-20	8	-2.38	.0359	2.91	5.09	8.880

$$\sum (F-f)^2/f = 22.418$$

Chi square percentage point at 4 degrees of freedom and .05 significance level = 9.488.

Therefore: Reject hypothesis of normality.

Figure 34. Chi Square Test For Normality -- Control, Before Television Installation

$n = 20 \qquad \bar{x} = 25.25 \qquad s = 5.00$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoretical	F-f	$(F-f)^2/f$
28-37	6	.55	.2912	5.83	.17	.005
25-28	5	-.05	.2287	4.57	.43	.040
22-25	4	-.65	.2223	4.45	-.55	.068
15-22	5	-2.05	.2376	4.75	.25	.013

$$\sum (F-f)^2/f = .126$$

Chi square percentage point at 1 degree of freedom and .05 significance level = 3.841

Therefore: Assume normality.

Figure 35. Chi Square Test For Normality -- Control During First Week Following Television Removal

$n = 56$ $\bar{x} = 25.19$ $s = 3.94$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoretical	F-f	$(F-f)^2/f$
32-40	3	1.73	.0418	2.34	.66	.186
29-32	4	.97	.1242	6.95	-2.95	1.250
27-29	7	.46	.1568	8.78	-1.78	.361
25-27	12	-.05	.1971	11.05	.95	.081
23-25	14	-.56	.1924	10.76	3.24	.980
21-23	14	-1.06	.1431	8.02	5.98	4.461
15-21	2	-2.58	.1396	7.82	-5.82	4.339

$$\sum (F-f)^2/f = 11.658$$

Chi square percentage point at 4 degrees of freedom and .05 significance level = 9.488

Therefore: Reject hypothesis of normality.

Figure 36. Chi Square Test for Normality -- Control During Third and Fourth Weeks Following Television Removal

$n = 90$ $\bar{x} = 25.56$ $s = 7.71$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoret-ical	F-f	$(F-f)^2/f$
38-64	5	1.61	.0537	4.83	.17	.006
34-38	5	1.08	.0864	7.77	-2.77	.990
31-34	5	.71	.0988	8.90	3.90	1.710
29-31	8	.45	.0875	7.87	.13	.002
27-29	13	.19	.0983	8.85	4.15	1.948
25-27	8	-.07	.1032	9.30	-1.30	.181
23-25	11	-.33	.1014	9.14	1.86	.378
21-23	10	-.59	.0931	8.39	1.61	.310
19-21	16	-.85	.0799	7.18	8.82	10.829
15-19	9	-1.37	.1124	10.11	-1.11	.121

$$\sum (F-f)^2/f = 16.375$$

Chi square percentage point at 7 degrees of freedom and .05 significance level = 14.067.

Therefore: Reject hypothesis of normality.

Figure 37. Chi Square Test for Normality -- Second Control, Before Television Installation

$n = 21$ $\bar{x} = 25.62$ $s = 3.25$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoretical	F-f	$(F-f)^2/f$
29-37	3	1.04	.1492	3.13	-.13	.005
27-29	3	.42	.1880	3.94	-.94	.224
25-27	6	.19	.2381	5.01	.99	.196
23-25	7	.81	.2157	4.53	2.47	1.345
21-23	2	1.42	.1312	2.76	-.76	.209

$$\sum (F-f)^2/f = 1.979$$

Chi square percentage point at 2 degrees of freedom and .05 significance level = 5.991.

Therefore: Assume normality.

Figure 38. Chi Square Test for Normality -- Second Control, During Television Functioning

$n = 19$ $\bar{x} = 29.11$ $s = 4.98$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoretical	F-f	$(F-f)^2/f$
34-40	4	.98	.1635	3.11	.89	.255
31-34	3	.38	.1885	3.58	-.58	.094
28-31	2	-.22	.2351	4.47	-2.47	1.366
25-28	6	-.83	.2096	3.98	2.02	1.023
22-25	4	-1.43	.1269	2.41	1.59	1.047

$$\sum (F-f)^2/f = 3.785$$

Chi square percentage point at 2 degrees of freedom and .05 significance level = 5.991.

Therefore: Assume normality.

Figure 39. Chi Square Test for Normality -- Second Control, During First Week Following Television Removal

$n = 71$ $\bar{x} = 26.79$ $s = 3.70$

Class Interval	Act. F	Limits In Std. Units	Area Under Curve	Theoretical	F-f	$(F-f)^2/f$
31-43	6	1.14	.1271	9.02	-3.02	1.012
29-31	12	.60	.1472	10.46	1.54	.237
27-29	19	.06	.2018	14.30	4.70	1.546
25-27	16	-.48	.2083	14.70	1.30	.115
23-25	13	-1.03	.1641	11.65	1.35	.156
20-23	5	-1.84	.1186	8.41	-3.41	1.381

$$\sum (F-f)^2/f = 4.447$$

Chi square percentage point at 3 degrees of freedom and .05 significance level = 7.815.

Therefore: Assume normality.

Figure 40. Chi Square Test for Normality -- Second Control During Third and Fourth Weeks Following Television Removal

Distribution of Total Number of Runs

Median = 63.5 N = 66 = Total readings

Number above = 33 = number below = m = n

Runs are broken down as follows:

Number of runs	Above	Below
1	7	9
2	4	2
3	1	3
4	1	1
5	1	1
6	1	1
7		1
9	1	
Totals	16	18

Grand total = 34

From table of limiting values for total number of runs above and below the median, Duncan (58), at .05 significance level, at m = n = 33, the reading is 26. Total runs = 34.

Therefore: Assume randomness.

Distribution of Lengths of Runs of Any One Class

From table of limiting values for lengths of runs on either side of the median, Duncan (59), the probability of getting at least one run of 10 for N = 50 is .05. The actual N = 66 and the maximum run is 9.

Therefore: Assume randomness.

Figure 41. Checks by Runs -- Experimental, Before Television Installation

Distribution of Total Number of Runs

Median = 61 N = 5

With a median of 61 there is a total of 4 runs of both classes (above and below the median). The reading from the table is 3 at m = n = 6, at p = .05 (significance level).

Therefore: Assume randomness.

Distribution of the Lengths of Runs for Any One Class

Lowest N in table is 10, and at p = .05, the maximum length of runs is 5.

Therefore: Assume randomness.

Figure 42. Checks by Runs -- Experimental, During Television Functioning

Distribution of Total Number of Runs

Median = 70.5 N = 24

Number above = 12 = number below = m = n

Number of runs	Above	Below
1	1	1
2	1	1
3	1	3
6	1	
Totals	4	5

Grand total = 9

From table at m = n = 12 and p = .05, the reading is 8.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 24, p = .05, the limiting value for total runs is between 7 and 8.

Therefore: Assume randomness.

Figure 43. Checks by Runs -- Experimental, During First and Second Weeks Following Television Removal

<u>Distribution of Total Number of Runs</u>

Median = 62 N = 33

m = n = 16

Number of runs	Above	Below
1	7	4
2	1	3
3	1	1
4	1	1
Totals	10	9

Grand Total = 19

From table at m = n = 16 and p = .05, the reading is 11.

Therefore: Assume randomness.

<u>Distribution of the Lengths of Runs of Any One Class</u>

From table for N = 30, p = .05, the limiting value for total runs is 8.

Therefore: Assume randomness.

Figure 44. Checks by Runs -- Experimental, During Third and Fourth Weeks Following Television Removal

Distribution of Total Number of Runs

Median = 33 N = 81

m = n = 40

Number of runs	Above	Below
1	5	11
2	9	3
3	3	2
11		1
15	1	
Totals	18	17

Grand total = 35

From table at m = n = 40 and p = .05, the reading is 33.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 50, p = .05, the limiting value for total runs is 10. For N = 81 runs larger than 10 suggest nonrandom influences.

Therefore: Reject hypothesis of randomness.

Figure 45. Checks by Runs -- Control, Before Television Installation

Distribution of Total Number of Runs

Median = 27 N = 11

m = n = 5

Number of runs	Above	Below
2	1	1
3	1	
4		1
Totals	2	2

Grand total = 4

From table at m = n = 5, p = .05, the total runs would be less than 3.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 10, p = .05, the limiting value for total runs is 5.

Therefore: Assume randomness.

Figure 46. Checks by Runs -- Control, During Television Functioning

Distribution of Total Number of Runs

Median = 25 N = 20

m = n = 10

Number of runs	Above	Below
1	2	2
2	1	
3		1
5		1
6	1	
Totals	4	4

Grand total = 8

From table at m = n = 10, p = .05, the total runs would be 7.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 20, p = .05, the limiting value for total runs is 7.

Therefore: Assume randomness.

Figure 47. Checks by Runs -- Control, During First Week Following Television Removal

Distribution of Total Number of Runs

Medoam = 24 N = 56

m = n = 28

Number of runs	Above	Below
1	7	11
2	3	1
3	5	5
Totals	15	17

Grand total = 32

From table at m = n = 28, p = .05, the total runs would be 22.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 50, p = .05, the limiting value for total runs is 10.

Therefore: Assume randomness.

Figure 48. Checks by Runs -- Control During Third and Fourth Weeks Following Television Removal

Distribution of Total Number of Runs

Median = 24 N = 90

m = n = 45

Number of runs	Above	Below
1	7	9
2	4	3
3	4	2
4	1	
5	1	2
8		2
14	1	
Totals	18	18

Grand total = 36

From table at m = n = 45, p = .05, the total runs would be 37.

Therefore: Reject hypothesis of randomness.

Figure 49. Checks by Runs -- Second Control Before Television Installation

Distribution of Total Number of Runs

Median = 26 N = 21

m = n = 10

Number of runs	Above	Below
1	4	2
2	2	2
3		1
4		1
Totals	6	6

Grand total = 12

From table at m = n = 10, p = .05, the total runs would be 6.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 20, p = .05, the limiting value for total runs is 5.

Therefore: Assume randomness.

Figure 50. Checks by Runs -- Second Control, During Television Functioning

Distribution of Total Number of Runs

Median = 27 N = 19

m = n = 9

Number of runs	Above	Below
1		1
2	1	
3	1	1
4		1
6	1	
Totals	3	3

Grand total = 6

From table at m = n = 10, p = .05, the total runs would be 6. Since the actual m = n = 9.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 19, p = .05, the limiting value is between 6 and 7.

Therefore: Assume randomness.

Figure 51. Checks by Runs -- Second Control, First Week Following Television Removal

Distribution of Total Number of Runs

Median = 27 N = 71

m = n = 35

Number of runs	Above	Below
1	14	9
2	3	5
3	1	1
4		1
5	1	2
7		1
Totals	19	19

Grand total = 38

From table at m = n = 35, p = .05, the total runs would be 28.

Therefore: Assume randomness.

Distribution of the Lengths of Runs of Any One Class

From table for N = 50, p = .05, the limiting value is 10.

Therefore: Assume randomness.

Figure 52. Checks by Runs -- Second Control, Third and Fourth Weeks Following Television Removal

F and t Tests for Experimental Operation

Test for Equality of Variances

H: $s_x^2 = s_y^2$ or $s_x = s_y$ $\alpha = .05$ $n_x = 66$ $n_y = 5$

s_x^2 = Sample variance before TV = 68.66

s_y^2 = Sample variance during TV = 9.30

Test statistic $F = s_x^2/s_y^2 = 68.66/9.30 = 7.36$

Criteria for rejection:

$$F \geqq F_{\alpha;n_x-1,n_y-1} \quad \text{or} \quad F \geqq F_{.050;65,4}$$

From table of percentage points of F distribution:

$$5.69 > F_{.050;65,4} > 5.67$$

Therefore: Reject the hypothesis that the variances are equal.

Test for Equality of Means

H: $\mu_x = \mu_y$ $\alpha = .05$

Test statistic, $t' = \dfrac{\bar{x} - \bar{y}}{\sqrt{s_x^2/n_x + s_y^2/n_y}}$

$$= \frac{65.14 - 60.60}{\sqrt{68.66/66 + 9.30/5}}$$

$$= 2.98$$

Figure 53. Experimental Operator Performance -- Before TV Installation vs Performance During TV Functioning. (Continued)

The associated degrees of freedom:

$$\nu = \frac{(s_x^2/n_x + s_y^2/n_y)^2}{(s_x^2/n_x)^2/(n_x + 1) + (s_y^2/n_y)^2/(n_y + 1)} - 2$$

$$= \frac{(68.66\ 66 + 9.30\ 5)^2}{(68.66/66)^2/67 + (9.30/5)^2/6} - 2$$

$$= 12.15$$

Criteria for rejection

$$|t| \geqq t_{\alpha;\nu} \quad \text{or} \quad |t| \geqq t_{.05;12.15}$$

From table of percentage points of the t distribution

$$1.782 > t_{.05;12.15} > 1.771$$

Therefore: Reject the hypothesis that the means are equal.

Figure 53. Experimental Operator Performance -- Before TV Installation vs Performance During TV Functioning. (Concluded)

F and t Tests for Experimental Operation

Test for Equality of Variances

$\alpha = .05 \qquad n_x = 24 \qquad n_y = 66$

Test statistic, $F = 68.68 = 1.00$

Criteria for rejection:

$F \geqq F_{.05;23,65}$

From table

$1.71 > F_{.05;23,65} > 1.69$

Therefore: Accept the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

$$\text{Test statistic, } t = \frac{\bar{x} - \bar{y}}{\sqrt{1/n_x + 1/n_y}\sqrt{\dfrac{\sum_{t=1}^{n_x}(x-\bar{x})^2 + \sum_{t=1}^{n_y}(y-\bar{y})^2}{n_x + n_y - 2}}}$$

$$= \frac{70.83 - 65.14}{\sqrt{1/24 + 1/66}\sqrt{\dfrac{1577.33 + 4450.00}{24 + 66 - 2}}}$$

$$= 2.96$$

Figure 54. Experimental Operator Performance Before TV Installation vs Performance During First and Second Weeks Following TV Removal. (Continued)

The associated degrees of freedom:

$$24 + 66 - 2 = 88$$

Criteria for rejection

$$|t| \geqq t_{\alpha; n_x + n_y - 2} \quad \text{or} \quad |t| \geqq t_{.05;88}$$

From table:

$$1.664 > t_{.05;88} > 1.660$$

Therefore: Reject the hypothesis that the means are equal.

Figure 54. Experimental Operator Performance Before TV Installation vs Performance During First and Second Weeks Following TV Removal. (Concluded)

F and t Tests for Experimental Operation

Test for Equality of Variances

$\alpha = .05 \quad n_x = 66 \quad n_y = 33$

Test statistic, $F = 68.66/41.66 = 1.65$

Criteria for rejection:

$$F \geqq F_{.05;65,32}$$

From table:

$$1.71 > F_{.05;65,32} > 1.69$$

Therefore: Reject the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

Test statistic, $t' = \dfrac{(65.14 - 63.30)}{\sqrt{68.66/66 + 41.66/33}}$

$= 1.21$

The associated degrees of freedom:

$$= \frac{(68.66/66 + 41.66/33)^2}{(68.66/66)^2/67 + (41.66/33)^2\ 34} - 2$$

$= 82.4$

Figure 55. Experimental Operator Performance Before TV Installation vs Performance During Third and Fourth Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t'| \geqq t_{.050;82.4}$$

From table:

$$1.664 > t_{.050;82.4} > 1.660$$

Therefore: Accept the hypothesis that the means are equal.

Figure 55. Experimental Operator Performance Before TV Installation vs Performance During Third and Fourth Weeks Following TV Removal. (Concluded)

F and t Tests for Experimental Operation

Test for Equality of Variances

$\alpha = .05 \quad n_x = 24 \quad n_y = 5$

Test statistic, $F = 68.66/9.30 = 7.38$

Criteria for rejection:

$$F \geqq F_{.05;23,4}$$

From table

$$5.79 > F_{.05;23,4} > 5.77$$

Therefore: Reject the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

Test statistic, $t' = \dfrac{70.83 - 60.06}{\sqrt{68.66/24 + 9.30/5}}$

$$= 4.93$$

The associated degrees of freedom:

$$= \frac{(68.66/24 + 9.30/5)^2}{(68.66/24)^2/25 + (9.30/5)^2/6} - 2$$

$$= 22.6$$

Figure 56. Experimental Operator Performance During TV Functioning vs Performance During First and Second Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t'| \geqq t_{.050;22.6}$$

From table:

$$1.717 > t_{.050;22.6} > 1.714$$

Therefore: Reject the hypothesis that the means are equal.

Figure 56. Experimental Operator Performance During TV Functioning vs Performance During First and Second Weeks Following TV Removal. (Concluded)

F and t Tests for Experimental Operation

Test for Equality of Variances

$\alpha = .05 \qquad n_x = 33 \qquad n_y = 5$

Test statistic, $F = 41.66/9.30 = 4.45$

Criteria for rejection:

$F \geqq F_{.05;32,4}$

From table

$5.75 > F_{.05;32,4} > 5.73$

Therefore: Accept the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

Test statistic, $t = \dfrac{63.30 - 60.60}{\sqrt{1/33 + 1/5}\ \sqrt{\dfrac{1333.0 + 37.2}{33 + 5 - 2}}}$

$= 3.45$

The associated degrees of freedom:

$= 33 + 5 - 2 = 36$

Figure 57. Experimental Operator Performance During TV Functioning vs Performance During Third and Fourth Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t| \geqq t_{.05;36}$$

From table:

$$1.697 > t_{.05;36} > 1.684$$

Therefore: Reject the hypothesis that the means are equal.

Figure 57. Experimental Operator Performance During TV Functioning vs Performance During Third and Fourth Weeks Following TV Removal. (Concluded)

F and t Tests for Experimental Operation

Test for Equality of Variances

$\alpha = .05 \quad n_x = 24 \quad n_y = 33$

Test statistic, $F = 68.66/41.66 = 1.65$

Criteria for rejection:

$F \geqq F_{.05;23,32}$

From table:

$1.88 > F_{.05;23,32} > 1.86$

Therefore: Accept the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

$$\text{Test statistic, } t = \frac{70.83 - 63.30}{\sqrt{1/24 + 1/33}\ \sqrt{\dfrac{1577.33 + 1333.00}{24 + 33 - 2}}}$$

$$= 3.88$$

Associated degrees of freedom:

$= 24 + 33 - 2 = 55$

Figure 58. Experimental Operator Performance During First and Second vs During Third and Fourth Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t| \geqq t_{.05;55}$$

From table:

$$1.676 > t_{.05;55} > 1.671$$

Therefore: Reject the hypothesis that the means are equal.

Figure 58. Experimental Operator Performance During First and Second vs During Third and Fourth Weeks Following TV Removal. (Concluded)

F and t Tests for Control Operation

Test for Equality of Variances

$\alpha = .05 \quad n_x = 11 \quad n_y = 20$

Test statistic, $F = 40.85/25.00 = 1.63$

Criteria for rejection

$F \geqq F_{.05;10,19}$

From table

$F_{.05;10,19} = 2.38$

Therefore: Accept the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

Test statistic, $t = \dfrac{27.63 - 25.25}{\sqrt{1/11 + 1/20}\sqrt{\dfrac{408.50 + 475.75}{11 + 20 - 2}}}$

$= 1.19$

The associated degrees of freedom:

$= 11 + 20 - 2 = 29$

Figure 59. Control Operator Performance During TV Functioning vs Performance During First Week Following TV Removal. (Continued)

Criteria for rejection:

$$|t| \geq t_{.05;29}$$

From table:

$$1.699 > t_{.05;29} > 1.697$$

Therefore: Accept the hypothesis that the means are equal.

Figure 59. Control Operator Performance During TV Functioning vs Performance During First Week Following TV Removal. (Concluded).

F and t Tests for Second Control Operation

Test for Equality of Variances

$\alpha = .05 \qquad n_x = 19 \qquad n_y = 21$

Test statistic, $F = 24.77/10.55 = 2.44$

Criteria for rejection:

$F \geqq F_{.05;18,20}$

From table:

$F = 2.15$

Therefore: Reject the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

Test statistic, $t' = \dfrac{29.11 - 25.62}{\sqrt{24.77/19 + 10.55/21}}$

$= 2.60$

The associated degrees of freedom:

$$= \frac{(24.77\ 19 + 10.55\ 21)^2}{(24.77/19)^2/20 + (10.55/21)^2/22} - 2$$

$= 30.6$

Figure 60. Second Control Operator Performance Durinv TV Functioning vs Performance During First Week Following TV Removal. (Continued)

Criteria for rejection:

$$|t| \geqq t_{.05;30.6}$$

From table:

$$1.697 > t_{.05;30.6} > 1.684$$

Therefore: Reject the hypothesis that the means are equal.

Figure 60. Second Control Operator Performance During TV Functioning vs Performance During First Week Following TV Removal. (Concluded)

F and t Tests for Second Control Operation

Test for Equality of Variances

$\alpha = .05 \qquad n_x = 71 \qquad n_y = 21$

Test statistic, $F = 13.71/10.55 = 1.20$

Criteria for rejection:

$F \geqq F_{.05;70,20}$

From table:

$1.95 > F_{.05;71,19} > 1.92$

Therefore: Accept the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

$$\text{Test statistic, } t = \frac{26.79 - 25.62}{\sqrt{1/71 + 1\ 21}\ \sqrt{\frac{959.9 + 211.0}{21 + 71 - 2}}}$$

$$= 1.25$$

The associated degrees of freedom:

$= 21 + 71 - 2 = 90$

Figure 61. Second Control Operator Performance During TV Functioning vs Performance During Third and Fourth Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t| \geqq t_{.05;90}$$

From table:

$$1.664 > t_{.05;90} > 1.660$$

Therefore: Accept the hypothesis that the means are equal.

Figure 61. Second Control Operator Performance During TV Functioning vs Performance During Third and Fourth Weeks Following TV Removal. (Concluded)

F and t Tests for Second Control Operation

Test for Equality of Variances

$\alpha = .05 \qquad n_x = 19 \qquad n_y = 71$

Test statistic, $F = 24.77/13.71 = 1.80$

Criteria for rejection:

$F \geqq F_{.05;18,70}$

From table:

$F = 1.75$

Therefore: Reject the hypothesis that the variances are equal.

Test for Equality of Means

$\alpha = .05$

$$\text{Test statistic, } t' = \frac{29.11 - 26.79}{\sqrt{24.77/19 + 13.71/71}}$$

$$= 1.90$$

The associated degrees of freedom:

$$= \frac{(24.77/19 + 13.71/71)^2}{(24.77/19)^2/20 + (13.71/71)^2/72} - 2$$

$$= 30.95$$

Figure 62. Second Control Operator Performance During First vs During Third and Fourth Weeks Following TV Removal. (Continued)

Criteria for rejection:

$$|t'| \geqq t_{.05;30.95}$$

From table

$$1.697 > t_{.05;30.95} > 1.684$$

Therefore: Reject the hypothesis that the means are equal.

Figure 62. Second Control Operator Performance During First vs During Third and Fourth Weeks Following TV Removal. (Concluded)

1. Rolls of 16 MM film taken with the memomotion camera, 100 feet each.

   a. Week of 8/13 - 8/18/62
   b. Week of 8/20 - 8/25/62
   c. Week of 8/27 - 9/1/62
   d. Week of 9/4 - 9/9/62
   e. Week of 10/29 - 11/4/62
   f. Week of 11/5 - 11/10/62
   g. Week of 11/12 - 11/16/62
   h. Week of 11/19 - 11/24/62

   This film is the basis for the data of Tables 1 through 12.

2. One 1800 foot roll of magnetic tape. It contains all recorded conversations made during the thesis experiment.

3. Three 1½ inch strips of 16 MM film cut from one of the rolls of item 1 above. Three enlarged negatives, 2½" x 4", and three enlarged prints, 4½" x 6½", were made from one of these film strips.

4. Negatives mentioned in item 3 above.

5. Prints mentioned in item 3 above.

6. Four typewritten copies of the transcript from item 2 above, of the conversation between the plant manager and the thesis writer.

Figure 63. List of Related Items Not Included in Thesis

Page 158 missing from thesis.

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